DOCUMENT RESUME

ED 223 902 CE 034 542

TITLE	Construction Mechanic Part I, 8-5. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Naval Construction Training Center, Port Hueneme, Calif.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	78
NOTE	907p.; For related documents, see CE 034 543-545
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF06/PC37 Plus Postage.
DESCRIPTORS	Audiovisual Aids; *Auto Mechanics; Behavioral Objectives; Course Content; *Diesel Engines; Educational Resources; *Electrical Systems; Engines; Learning Activities; Lesson Plans; *Mechanics (Process); *Motor Vehicles; Postsecondary Education; Power Technology; Secondary Education; Technical Education; *Units of Study; Vocational Education
IDENTIFIERS	Military Curriculum Project

ABSTRACT

This course, adapted from military curriculum materials for use in vocational and technical education, is the first of a two-course series that teaches students to maintain and repair automotive and construction equipment using either gasoline or diesel engines. It covers basic combustion engine principles and electrical system principles as well as troubleshooting, diagnosis, and adjustment procedures. The course contains two phases covering 105 hours of instruction. Phase 1 on gasoline engines contains two units including an introduction to the course and information on gasoline-engine repairs and adjustments. Phase 2 on diesel engines covers maintenance and repair to Caterpillar, International, General Motors, and Cummins diesel engines. The course contains both student and teacher materials. Printed instructor materials include a curriculum outline for the course and instructor's guides for each phase. The curriculum outline includes an introduction to the course; outline of instruction; outline of training objectives; lists of texts, references, tools, equipment, materials, training aids and devices, training aid equipment; and a master schedule. The instructor guides include the lesson plans for each unit. Student materials include 7 job sheets, 11 information sheets, and 1 work sheet. (KC)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

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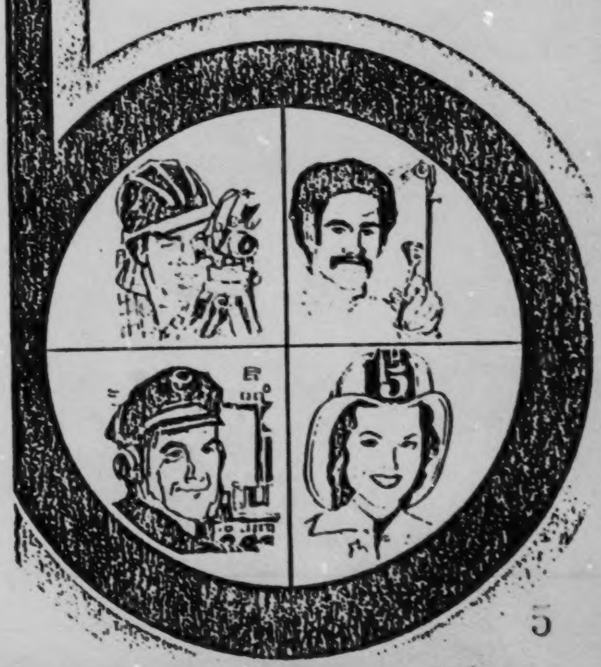

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

CONSTRUCTION MECHANICS, CLASS A, PART 1

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CONSTRUCTION MECHANIC, CLASS A, PART I

Classroom Course

Developed by:

United States Navy

Development and Review Dates:

May 1975

D.O.T. No.:

620.281

Occupational Area:
Engine Mechanics

Target Audiences:

Grades 11-adult

Print Pages:

535

Cost:

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Phase 1 – *Gasoline Engines*												
Unit 1 – Introduction	●			●	★	★	●	★			●	
Unit 2 – Gasoline Engine Repair and Adjustment	●			●	★	★	●	★		★	●	●
Phase 2 – *Diesel Engines*												
Unit 1 – Caterpillar Diesel Engine Operation and Maintenance	●			●	●	★	●	★		★	●	●
Unit 2 – International Diesel Engine Operation and Maintenance	●			●	★	★	●	★		★	●	●
Unit 3 – General Motors Diesel Engine Operation and Maintenance	●			●	★	★	●	★		★	●	●
Unit 4 – Cummins Diesel Engine Operation and Maintenance	●			●	★	★	●	★		★	●	●

★ Materials are recommended but not provided.

THE CENTER FOR VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

Expires July 1, 1978

Course Description:

This course is the first of a two-course series which teaches students to maintain and repair automotive and construction equipment using either gasoline or diesel engines. It covers basic combustion engine principles and electrical system principles as well as troubleshooting, diagnosis, and adjustment procedures. This course contains two phases covering 105 hours of instruction.

Phase 1 – *Gasoline Engines* contains two units including an introduction to the course and information on gasoline engine repair and adjustment. One orientation and registration lesson was deleted. The units, lessons, and hours follow:

Unit 1 – **Introduction**

1.1.2 Study Techniques (1 hour classroom)
1.1.3 Safety Policies (1 hour classroom)

Unit 2 – **Gasoline Engine Repair and Adjustment**

1.2.1 Internal Combustion Engine Principles (15 hours classroom, 5 hours practical)
1.2.2 Electrical System Principles (18 hours classroom, 4 hours practical)
1.2.3 Gasoline Engine Disassembly (4 hours classroom, 7 hours practical)
1.2.4 Inspection and Measuring of Engine Components (5 hours classroom, 10 hours practical)
1.2.5 Gasoline Engine Assembly (2 hours classroom, 8 hours practical)
1.2.6 Gasoline Engine Trouble, Diagnosis and Adjustment (10 hours classroom, 15 hours practical)

Phase 2 – *Diesel Engines* contain four units covering 121 hours of instruction. A fifth unit was deleted because it deals with a specific piece of military tactical equipment.

Unit 1 – **Caterpillar Diesel Engine Operation and Maintenance**

2.1.1 Caterpillar Diesel Engine Operation (5 hours classroom, 2 hours practical)
2.1.2 Caterpillar Diesel Engine Maintenance (11 hours classroom, 13 hours practical)

Unit 2 – **International Diesel Engine Operation and Maintenance**

2.2.1 International Diesel Engine Operation (2 hours classroom, 2 hours practical)
2.2.2 International Diesel Engine Maintenance (11 hours classroom, 18 hours practical)

Unit 3 – **General Motors Diesel Engine Operation and Maintenance**

2.3.1 General Motors Diesel Engine Operation (4 hours classroom, 2 hours practical)
2.3.2 General Motors Diesel Engine Maintenance (10 hours classroom, 16 hours practical)

Unit 4 – **Cummins Diesel Engine Operation and Maintenance**

2.4.1 Cummins Diesel Engine Operation (2 hours classroom, 2 hours practical)
2.4.2 Cummins Diesel Engine Maintenance (8 hours classroom, 13 hours practical)

This course contains both student and teacher materials. Printed instructor materials include a curriculum outline for the course, and instructor's guides for each phase. The curriculum outline includes an introduction to the course; outline of instruction; outline of training objectives; and lists of texts, references, tools, equipment, materials, training aids and devices, training aids equipment; and a master schedule. The instructor guides include the lesson plans for each unit. Student materials include 7 job sheets, 11 information sheets, and 1 work sheet.

This two-course series requires a considerable amount of additional material. Twenty-seven recommended commercial texts and technical manuals are not provided. Seven additional military and commercial references are suggested. Twenty-three military and fourteen commercial films are recommended but are not provided for use. Twenty-two slide films, thirty-seven slides, two transparencies, and eight charts are also suggested. The instructor may be able to substitute similar materials which are on-hand for these items.

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CURRICULUM OUTLINE
FOR
CONSTRUCTION MECHANIC, CLASS A

A-610-0022

Prepared By

U.S. NAVAL CONSTRUCTION TRAINING CENTER
Port Hueneme CA. 93043

MAY 1975

8-5
8-6

Encl. ([illegible])

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TOTAL	22

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TITLE PAGE

TITLE: Construction Mechanic "A"

COURSE NO.: A-610-0022

COURSE LENGTH: 13 Weeks, 05 hours

TAUGHT AT: Naval Construction Training Center, Port Hueneme, Ca. 93043
Naval Construction Training Center, Gulfport, Ms. 39501

CLASS CAPACITY: Normal: 20
Maximum: 24
Minimum: 16

INSTRUCTOR REQUIREMENTS PER CLASS: Class: 24/1
Pract: 6/1
Field: 24/1

COURSE CURRICULUM MODEL MANAGER: Naval Construction Training Center,
Port Hueneme, California 93043

CURRICULUM CONTROL: Chief of Naval Technical Training

QUOTA MANAGEMENT AUTHORITY: Chief of Naval Technical Training

QUOTA CONTROL: BUPERS

APPROVAL/IMPLEMENTATION DATE: Chief of Naval Technical Training ltr
N3351:stb, 1500, Ser 33/445 of 20 May 1975

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INTRODUCTION

1. This curriculum was developed by Naval Construction Training Center, Port Hueneme, California 93043, as Course Model Manager, and is effective upon final approval of the Chief of Naval Technical Training.

2. Commands are invited to submit explicit comments on the content of this curriculum to the Commanding Officer, Naval Construction Training Center, Port Hueneme, California 93043, with copies to the Chief of Naval Technical Training, Naval Air Station Memphis (75), Millington, Tennessee 38054 and the Commanding Officer, Naval Construction Training Center, Gulfport, Mississippi 39501.

3. Training Notes

This course has been developed and designed in accordance with the principles of systems engineering. In order to insure that the objectives of each unit are met, it is expected that the instructor will teach the topics as outlined in accordance with the referenced publications. Deviation is allowed only to exceed or supplement the required instruction. Lesson outlines in the instructor guides are to be used as a guide in the presentation of the lesson. While it is compulsory that all objectives of each training period be met, it is recognized that the specified times established for each lesson may vary with the achievement level of each group of students, the number of students per cycle, the instructor-to-student ratio, and the availability of facilities. It is the responsibility of the school to provide for the efficient implementation and administration of this publication and to ensure that each of the learning activities outlined herein is taught in a manner which provided a maximum gain in knowledge and skill for each student.

4. Training Methods

a. The traditional methods of conference, demonstration and practical exercise are used during this course of instruction. In keeping with changes which potentially will benefit the instruction, other methods are also included:

(1) Information presentations: These are designed primarily to make information available in a group setting, have no objectives, and are not instructional. No tests are given on information presentations.

(2) Self-study text materials: These individualized materials do have objectives and are instructional and will be tested at the end of each section of the student workbook.

(3) Group audio-visual presentations: These presentations can be either informational or instructional.

(4) Progress evaluation test: Tests that are inserted at critical points to determine student's capabilities to perform objectives.

(5) Group interactive lecture: Group participates by responding to situations presented verbally by the instructor or in the workbooks provided to the students.

b. Schools will emphasize the importance of performance-orientated training wherein learning-by-doing rather than listening and watching is practiced. Time devoted to the traditional methods of instruction will be limited in favor of the more recent methods outlined in paragraph 4a. Although some of the methods depend to a great extent on availability of audio-visual aids, there are other alternatives that can be developed at the training center using existing material.

c. The student learns best in a job-relevant environment. Time devoted to lectures, conferences and demonstrations should be held to the minimum required for explaining the objectives, course organization, safety precautions, and other introductory-type subjects pertinent to the course.

5. Testing Concepts:

Criterion testing (tests designed to measure performance of specific objectives) will be used to measure student performance. Each student will be tested on each learning objective to the level of proficiency stated in the objective. A series of performance tests for each scheduled evaluation is provided at the end of each unit. Each test requirement or problem is closely related to specific training objectives and performance standards. Standards of proficiency are stated explicitly in performance tests. Proficiency testing is conducted using the pass/fail, go/no-go technique. Student performance during the formative tests will provide indicators as to need for additional training on an individual or group basis. Performance on the pass/fail tests conducted after each phase of the course provides the basis for determining whether or not a student will be graduated. Unit tests will be used in determining class standing and honor graduates.

6. How to Use Instructor Guides.

Instructor Guides are provided for each topic and include supporting instructional materials and aids identified by the topic number and preceded by a letter code designation. The letter code key is as follows:

AS - Assignment Sheet
JS - Job Sheet
IS - Information Sheet
CN - Class Notes
TR - Transparency
OS - Operation Sheet
T - Test
FT - Final Test
DS - Diagram Sheet
PS - Problem Sheet
PE - Performance Evaluation
WB - Workbook
G - Definition of Item in General

A complete list of all supporting materials and aids is documented with full descriptive titles in ANNEX I thru VII.

The instructor guides are intended to be used as master lesson plans subject to personalization by the individual instructor. In all cases, it is expected that the instructor will study the references in preparation for annotating the guide. It is also expected that each instructor will develop an appropriate introduction for each topic that will (1) create interest, (2) show the value of the topic to the student, (3) relate the topic to previous and future topics in the course, and (4) communicate the learning objectives to the student. Well prepared introductions will then provide the important motivational conditioning to establish readiness and effect for learning appropriate to each topic.

The first page of each instructor guide contains the following functional information:

1. Topic of Lesson
2. Time in Periods
3. References
4. Instructional Aids
5. Instructional Materials
6. Objectives (Terminal and Enabling)
7. Topic Criterion Test (as applicable)
8. Homework Assignment (when applicable)

The pages following page 1 of each instructor guide provide in a three-column format the teaching/learning procedures for conducting the lesson. The left-hand column includes the outline of instructional content required by the objectives; the center column includes recommended instructor activities or methodology; the right-hand column contains recommended student learning activities.

a. While the methodology and student learning activities documented in each instructor guide have been tested and proven to be effective for the lead school, those schools implementing this curriculum are encouraged to exercise creativity in designing learning exercises and conceiving methods and techniques to meet course objectives.

b. Instructors and supervisors of instruction should constantly evaluate the program and seek new and more effective methods, content, and procedures to improve their instruction. When changes in this curriculum become necessary because of new developments or because of needs that become evident through experience gained in using the curriculum, the school command is encouraged to take appropriate action. The types of changes and the conditions under which they will be made are as follows:

(1) Type A changes and those of course length; change in title of the course; or addition, deletion or alternation of blocks of subject matter to such an extent that the objectives of courses are changed, or that logistics, personnel allocations, funds and the like become involved. For Type A changes, the CNTECHTRA (Code 0162A) must participate in the planning, development and execution. Type A changes may not be made effective until approved by the Chief of Naval Technical Training.

(2) Type B changes are those within established structure of the course such as changes in instructional emphasis that are brought about by changes in topic content or time re-allocation (other than minor adjustments in time), changes in instructional procedures, and similar actions that will alter the objectives of a topic. For Type B changes, approval of the Chief of Naval Technical Training must be gained prior to implementing the changes.

(3) Type C changes include corrections of clerical errors; insertion of titles and designations of new films; publications, and equipment; minor adjustments in time allocations; additional suggestions to assist the instructor and so forth. For Type C changes, the Chief of Naval Technical Training must be notified in writing of the nature of the changes, with sufficient information on the mechanics of the changes to make possible the maintenance of an up-to-date copy of the curriculum. In order to avoid unnecessary paper work, Type C changes may be accumulated and reported only when the quantity or occasion warrants.

c. Formative Test: During the classroom phase of the instruction at specific checkpoints identified by the instructor, informal written tests will be administered to demonstrate mastery of specific subjects. These tests are designed to reinforce learning. Tests are administered at the end of each unit of instruction. Formal tests may vary from 10 - 25 multiple-choice questions and will have bearing to influence class standing and to determine honor graduates.

7. Peer Instruction.

It is envisioned that those students who learn faster or who have previously developed a particular skill can be used (after demonstrating proficiency in the subject) as peer instructors to assist slow learners. This technique enhances motivation and early subject mastery while minimizing requirements. Care should be taken not to pair students with widely disparate learning abilities. i.e., a student who has finished step 10 should not be paired with a student who is finishing step 2. He should help a student who is finishing step 8 or 9 and a student who has finished step 3 or 4 should help the student at step 2. In this way, there is a better chance that there will be no resentment of the peer instructor and he will also receive reinforcement from the instruction, having just completed the task himself.

COURSE DATA PAGE

COURSE MISSION: To provide basic technical knowledge and skills in performing maintenance and repair of automotive and construction equipment in preparation for immediate usefulness to the construction forces as Construction Mechanics.

PREREQUISITES: Selected CN, CA, SN, FN and candidates should be volunteers for Group VIII ratings.

OBLIGATED SERVICE: See TRANSMAN, NAVPERS 15909

SECURITY CLEARANCE REQUIRED: None.

NEC GAINED: None

PHYSICAL REQUIREMENTS: None

PREREQUISITE TRAINING AND/OR BASIC BATTERY TEST SCORES REQUIRED:

USN - GCT + Mech + Shop Pract = 150
USNR - GCT + Mech = 100

GRADING WEIGHT FACTORS: Performance of tasks throughout the course will be graded on a go/no go basis with written tests given at the end of each topic.

Final result to be class ranking specifically designed to enable the Commanding Officer to comply with Bureau of Naval Personnel directives relative to class standings.

OUTLINE OF INSTRUCTION

PHASE 1

GASOLINE ENGINES

TOPIC	UNIT 1	CLASS	PRACT	TOTAL	PAGE
	Introduction				
1.1.0	NAVCONSTRACEN Indoctrination	4	0	4	5
1.1.1	Registration and Orientation	1	0	1	5
1.1.2	Study Techniques	1	0	1	5
1.1.3	Safety Policies	1	0	1	5
		7	0	7	
	UNIT 2				
	Gasoline Engine Repair and Adjustment				
1.2.1	Internal Combustion Engine Principles	15	5	20	6
1.2.2	Electrical System Principles	18	4	22	6
1.2.3	Gasoline Engine Disassembly	4	7	11	6
1.2.4	Inspection and Measuring of Engine Components	5	10	15	6
1.2.5	Gasoline Engine Assembly	2	8	10	6
1.2.6	Gasoline Engine Trouble, Diagnosis and Adjustment	10	15	25	7
		54	49	103	

PHASE 2

DIESEL ENGINES

TOPIC	UNIT	CLASS	PRACT	TOTAL	PAGE
	UNIT 1				
	Caterpillar Diesel Engine Operation and Maintenance				
2.1.1	Caterpillar Diesel Engine Operation	5	2	7	7
2.1.2	Caterpillar Diesel Engine Maintenance	11	13	24	7
		16	15	31	
	UNIT 2				
	International Diesel Engine Operation and Maintenance				
2.2.1	International Diesel Engine Operation	2	2	4	8
2.2.2	International Diesel Engine Maintenance	11	18	29	8
		13	20	33	

TOPIC	UNIT 3	CLASS	PRACT	TOTAL	PAGE
	General Motors Diesel Engine Operation and Maintenance				
2.3.1	General Motors Diesel Engine Operation	4	2	6	8
2.3.2	General Motors Diesel Engine Maintenance	10	16	26	8
		14	18	32	
	UNIT 4				
	Cummins Diesel Engine Operation and Maintenance				
2.4.1	Cummins Diesel Engine Operation	2	2	4	9
2.4.2	Cummins Diesel Engine Maintenance	8	13	21	9
		10	15	25	
	UNIT 5				
	LD465-1 Multifuel Engine Operation and Maintenance				
2.5.1	LD465-1 Multifuel Engine Operation	3	2	5	9
2.5.2	LD465-1 Multifuel Engine Maintenance	8	15	23	10
		11	17	28	

PHASE 3

AUTOMOTIVE CHASSIS AND POWER TRAIN

	UNIT 1				
	Automotive Chassis and Power Train Maintenance				
3.1.1	Suspension System Service	5	8	13	10
3.1.2	Automotive Power Train Service	6	29	35	10
3.1.3	Brake System Service	7	20	27	11
3.1.4	Servicing the M-715 1 1/4 Ton Cargo Truck	4	4	8	11
		22	61	83	

PHASE 4

HEAVY EQUIPMENT CHASSIS AND POWER TRAIN

	UNIT 1				
	Crawler Tractor Power Train Maintenance				
4.1.1	Oxy-Mapp Gas Cutting	2	4	6	11
4.1.2	Construction Equipment Power Trains	12	30	42	12
4.1.3	Adjustment of International Model 260 Cable Control Unit	2	2	4	12
		16	36	52	

TOPIC	UNIT 2	CLASS	PRACT	TOTAL	PAGE
	Graduation				
4.2.1	Graduation	$\frac{0}{0}$	$\frac{1}{1}$	$\frac{1}{1}$	

* Total Classroom Periods - 163
* Total Practical Periods - 232
Total Periods for Course - 395

Total Weeks for Course - 13 Weeks and 5 Hours

** Total GMT Periods - 66
*** Total Admin Time - 9 hours

* All periods represent 60 minutes of actual instruction

** GMT - General Military Training required by OPNAV Instructions 1500.22 Series, 6330.1 Series and other current instructions to include physical training, upward, drug and alcohol abuse, etc.

*** Admin Time - Time before graduation to permit out-processing of students, i.e. shots, JAMTO, text book return, course critique, BEQ and school field day.

OUTLINE OF TRAINING OBJECTIVES

UNIT 1.1 INTRODUCTION Contact Hours: 7

Terminal Objective: Upon completion of this unit each student will have registered for the course, received course textbooks, answered questions pertaining to key points on the organization, mission, and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, met his counselor, stated the standards of the school, described the benefits that can be derived from good study texhniques, listed the factors contributing to the enhancement of good study techniques, stated how to report accidents or fires and listed the safety practices that will be enforced in the school.

Topic 1.1.0 NAVCONSTRACEN INDOCTRINATION Contact Hours: 4

Enabling Objectives: Upon completion of this topic each student will be able to answer questions pertaining to key points on the organization, mission and regulations of CBC and NAVCONSTRACEN. The student will complete Response Sheet 001/911C with 100% accuracy.

Topic 1.1.1 REGISTRATION AND ORIENTATION Contact Hours: 1

Enabling Objectives: Upon completion of this topic each student will have registered for the course, received textbooks, met his class counselor, answered questions pertaining to the organization, mission and regulations of the school and stated the standards of the school without reference to written material.

Topic 1.1.2 STUDY TECHNIQUES Contact Hours: 1

Enabling Objectives: Upon completion of this topic each student will have described the benefits that may be derived from good study techniques and stated the factors contributing to the enhancement of good study techniques.

Topic 1.1.3 SAFETY Contact Hours: 1

Enabling Objectives: Upon completion of this topic each student will be able to properly report fires and accidents and list the safety practices that will be enforced in this school.

UNIT 1.2 INTERNAL COMBUSTION ENGINES Contact Hours: 103

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1, Gasoline Engine Disassembly, Inspection and Assembly and CM "A" JS 1.2.6.1, Gasoline Engine Diagnosis and Adjustment. Upon completion of assembly and tune up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of $37^{\circ} - 42^{\circ}$, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Topic 1.2.1 INTERNAL COMBUSTION ENGINE PRINCIPLES Contact Hours: 20

Enabling Objectives: Upon completion of this topic each student will be able to identfiy and select with 100% accuracy all engine parts while considering principles of operation of an internal combustion engine. He will be evaluated on a continuing basis. Throughout the engine disassembly, measuring and inspection of parts and reassembly sections of CM "A" JS 1.2.3.1.

Topic 1.2.2 ELECTRICAL SYSTEM PRINCIPLES Contact Hours: 22

Enabling Objectives: Upon completion of this topic each student will be able to identify by name the following electrical system components: The ignition system, the cranking system, the charging system, the lighting system, and the accessory system and explain the operating principles of each system with 100% accuracy. Each student will be evaluated on a continuing basis throughout engine disassembly, assembly and specifically CM "A" JS 1.2.6.1, Gasoline Engine Trouble Diagnosis and Adjustment.

Topic 1.2.3 GASOLINE ENGINE DISASSEMBLY Contact Hours: 11

Enabling Objectives: Upon completion of this topic each student will be able to disassemble a six cylinder gasoline engine while working as a member of a two (2) man team, using a Ford, 240 cubic inch engine. He will use all appropriate handtools, special tools and shop equipment. The task will be accomplished while adhering to manufacturer's specifications and recommendations without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, Gasoline Engine Disassembly, Inspection and Assembly.

Topic 1.2.4 INSPECTION AND MEASURING OF ENGINE PARTS Contact Hours: 15

Enabling Objectives: Upon completion of this topic each student will be able to clean, inspect and measure engine parts of a Ford 240 cubic inch gasoline engine while working as a member of a two (2) man team. He will use appropriate handtools, special tools, measuring instruments and cleaning materials. All measurements will be recorded in appropriate spaces on Job Sheet and compared to manufacturer's specifications to determine extent of wear. All procedures will conform to manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, Gasoline Engine Disassembly, Inspection and Assembly.

Topic 1.2.5 GASOLINE ENGINE ASSEMBLY Contact Hours: 10

Enabling Objectives: Upon completion of this topic each student will be able to assemble a six cylinder gasoline engine while working as a member of a two (2) man team, using a Ford, 240 cubic inch engine. He will use all appropriate handtools, special tools, shop equipment and materials. The task will be accomplished while conforming to manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, Gasoline Engine Disassmebly, Inspection and Assembly.

Topic 1.2.6 GASOLINE ENGINE TROUBLE DIAGNOSIS AND ADJUSTMENT Contact Hours: 25

Enabling Objectives: Upon completion of this topic each student will be able to test, tune and troubleshoot a six cylinder gasoline engine using a Ford, 240 cubic inch engine. He will use appropriate handtools and test equipment. All performances will conform to procedures established by Job Sheet CM "A" JS 1.2.6.1, Gasoline Engine Diagnosis and Adjustment. The engine will be tuned to meet manufacturer's specifications as to ignition timing of 6° B.T.C., dwell 37° - 42°, idle speed 550 rpm and intake manifold vacuum of 18 - 21 inches. His performance will comply with Job Sheet procedures without error.

UNIT 2.1 CATERPILLAR DIESEL ENGINE OPERATION AND MAINTENANCE Contact Hours: 31

Terminal Objective: Upon completion of this unit each student will be able to operate and service Caterpillar diesel engines, models D-342 and D-3306. He will use appropriate hand tools, special tools and shop equipment. His performance will conform to manufacturer's recommendations as outlined in the Job Sheet CM "A" JS 2.1.1.1, Maintenance of Caterpillar Diesel Engines, without error.

Topic 2.1.1 CATERPILLAR DIESEL ENGINE OPERATION Contact Hours: 7

Enabling Objectives: Upon completion of this topic each student will be able to prestart check, start, run and secure Caterpillar diesel engines, models D-342 and D-3306, while monitoring instruments and interpreting readings. All performance will conform to manufacturer's recommendations as stated in the Job Sheet CM "A" JS 2.1.1.1 Maintenance of Caterpillar Diesel Engines, without error.

Topic 2.1.2 CATERPILLAR DIESEL ENGINE MAINTENANCE Contact Hours: 24

Enabling Objectives: Upon completion of this topic each student will be able to service Caterpillar diesel engines models D-342 and D-3306 using appropriate handtools, special tools and shop equipment. Specifically he will service cranking systems, fuel systems and adjustment of engine valve systems. All tasks will meet manufacturer's specifications as specified in Job Sheet CM "A" JS 2.1.1.1, Maintenance of Caterpillar Diesel Engines, without deviation.

UNIT 2.2 INTERNATIONAL DIESEL ENGINE MAINTENANCE Contact Hours: 33

Terminal Objective: Upon completion of this unit each student will be able to operate and service International diesel engine model 429 while working as a member of a two (2) man team. He will use all appropriate handtools, special tools and shop equipment. These tasks will consist of engine operation followed by service to the fuel system, cooling system and lubricating system. All performance will comply, without deviation, to manufacturer's recommendations as specified in the Job Sheet CM "A" JS 2.2.1.1, Maintenance of International Diesel Engine.

Topic 2.2.1 INTERNATIONAL DIESEL ENGINE OPERATION Contact Hours: 4

Enabling Objectives: Upon completion of this topic each student will be able to prestart check, start, operate and secure International diesel engine model 429 while working as a member of a two (2) man team. Additionally, he will monitor instruments and interpret readings. All performance will conform without error to manufacturer's recommendations as specified in the Job Sheet CM "A" JS 2.2.1.1, Maintenance of International Diesel Engines.

Topic 2.2.2 INTERNATIONAL DIESEL ENGINE MAINTENANCE Contact Hours: 29

Enabling Objectives: Upon completion of this topic each student will be able to service International diesel engine model 429, while working as a member of a two (2) man team. He will use all appropriate handtools, special tools and shop equipment. Specifically, he will service fuel injection system, scavenging system, cooling system and lubricating system. All tasks will conform to manufacturer's recommendations as stated in Job Sheet CM "A" JS 2.2.1.1, Maintenance of International Diesel Engines.

UNIT 2.3 GENERAL MOTORS DIESEL ENGINE MAINTENANCE Contact Hours: 32

Terminal Objective: Upon completion of this unit each student will be able to operate and service General Motors 71 series diesel engines while using appropriate hand tools, special tools and materials. He will operate the engine and conduct service procedures to the fuel system, cooling system, lubricating system and scavenging system with all tasks conforming without error to manufacturer's specifications and recommendations as specified in Job Sheet CM "A" JS 2.3.1.1, Maintenance of General Motors Diesel Engines.

Topic 2.3.1 GENERAL MOTORS DIESEL ENGINE OPERATION Contact Hours: 6

Enabling Objectives: Upon completion of this topic each student will be able to operate a General Motors 71 series diesel engine. He will prestart check, start, run and secure the engine, while monitoring the instruments and interpreting their readings to determine normal or abnormal function of engine systems as related to the two stroke cycle principle of operation. All tasks will be in accordance with manufacturer's specifications, without error, as outlined in the Job Sheet CM "A" JS 2.3.1.1, General Motors Operation and Maintenance.

Topic 2.3.2 GENERAL MOTORS DIESEL ENGINE MAINTENANCE Contact Hours: 26

Enabling Objectives: Upon completion of this topic each student will be able to service General Motors 71 series diesel engines while using appropriate handtools, special tools, and shop equipment. He will service the scavenging system, lubricating system, cooling system and fuel system. All tasks will conform to manufacturer's specifications without deviation, as specified in the Job Sheet CM "A" JS 2.3.1.1, Maintenance of General Motors Diesel Engines.

UNIT 2.4 CUMMINS DIESEL ENGINE MAINTENANCE Contact Hours: 25

Terminal Objective: Upon completion of this unit each student will be able to operate and service the Cummins N.H. 250 diesel engine while using applicable handtools, special tools, and shop equipment. Specifically, he will operate a Cummins diesel engine and service the fuel system, cooling system and scavenging system. All tasks will meet manufacturer's specifications and recommendations without deviation as specified in Job Sheet CM "A" JS 2.4.1.1, Maintenance of Cummins Diesel Engines, without deviation.

Topic 2.4.1 CUMMINS DIESEL ENGINE OPERATION Contact Hours: 4

Enabling Objectives: Upon completion of this topic each student will be able to operate a Cummins N.H. 250 diesel engine. He will prestart check, start, run and secure the engine while monitoring instruments, and interpreting their readings. His performance shall conform to manufacturer's recommendations, without error, as specified in Job Sheet CM "A" JS 2.4.1.1, Maintenance of Cummins Diesel Engines.

Topic 2.4.2 CUMMINS DIESEL ENGINE MAINTENANCE Contact Hours: 21

Enabling Objectives: Upon completion of this topic each student will be able to service a Cummins N.H. 250 diesel engine while using appropriate handtools, special tools, and shop equipment. Specifically, he will service the fuel system, cooling system, lubricating system and scavenging system. All tasks will conform to manufacturer's specifications as specified in the Job Sheet CM "A" JS 2.4.1.1, Maintenance of Cummins Diesel Engines, without deviation.

UNIT 2.5 LD465-1 MULTIFUEL ENGINE MAINTENANCE Contact Hours: 28

Terminal Objective: Upon completion of this unit each student will be able to operate and service the LD465-1 Multifuel engine using appropriate handtools, special tools, and shop equipment. Specifically, he will service the fuel system, cooling system, lubricating system and scavenging system. His performance will conform to manufacturer's specifications as specified in Job Sheet CM "A" JS 2.5.1.1, LD465-1 Multifuel Engine Maintenance, without deviation.

Topic 2.5.1 LD465-1 MULTIFUEL ENGINE OPERATION Contact Hours: 5

Enabling Objectives: Upon completion of this topic each student will be able to prestart check, start, run and secure the LD465-1 Multifuel engine while monitoring instruments and interpreting readings. All performance will conform to manufacturer's recommendations as stated in the Job Sheet CM "A" JS 2.5.1.1, LD465-1 Multifuel Engine Maintenance, without deviation.

Topic 2.5.2 LD465-1 MULTIFUEL ENGINE MAINTENANCE Contact Hours: 23

Enabling Objectives: Upon completion of this topic each student will be able to service the LD465-1 Multifuel engine using appropriate handtools, special tools and shop equipment. Specifically, he will service the fuel system, cooling system, lubricating system and scavenging system. All tasks will conform to manufacturer's specifications as specified in Job Sheet CM "A" JS 2.5.1.1, LD465-1 Multifuel Engine Maintenance, without deviation.

UNIT 3.1 AUTOMOTIVE CHASSIS AND POWER TRAIN MAINTENANCE Contact Hours: 83

Terminal Objective: Upon completion of this unit each student, while working as a member of a two (2) man team, will be able to service automotive chassis and power train components using appropriate handtools, special tools, shop equipment and materials. Specifically, he will service suspension system, power train and brake system, of the M715, 1 1/4 ton, cargo truck. All tasks will conform to manufacturer's specifications, without error, as specified in the Job Sheet CM "A" JS 3.1.1.1, Servicing the Power Train of the M715, 1 1/4 ton Cargo Truck.

Topic 3.1.1 SUSPENSION SYSTEM SERVICE Contact Hours: 13

Enabling Objectives: Upon completion of this topic each student, while working as a member of a two (2) man team, will be able to service suspension system components using appropriate handtools, special tools, and shop equipment. Specifically, he will service tires, tubes, wheels, and steering systems of the M715, 1 1/4 ton cargo truck. All tasks will conform to manufacturer's specifications and recommendations without error as specified in the Job Sheet CM "A" JS 3.1.1.1, Servicing the Power Train of the M715, 1 1/4 Ton Cargo Truck.

Topic 3.1.2 AUTOMOTIVE POWER TRAIN SERVICE Contact Hours: 35

Enabling Objectives: Upon completion of this topic each student, while working as a member of a two (2) man team, will be able to service power train components using handtools, special tools, shop equipment and materials. These tasks will consist of service to clutch, transmission, drive shafts, and drive axles of the M715, 1 1/4 ton cargo truck. All performance will conform to manufacturer's specifications without error as specified in Job Sheet CM "A" JS 3.1.1.1, Servicing the Power Train of the M715 1 1/4 Ton Cargo Truck.

Topic 3.1.3 BRAKE SYSTEM SERVICE Contact Hours: 27

Enabling Objectives: Upon completion of this topic each student will be able to service hydraulic brake system, while working as a member of a two (2) man team. Using appropriate handtools, special tools, and materials and shop equipment. He will replace worn hydraulic system parts and bleed and adjust the system of the M715, 1 1/4 ton cargo truck. All performance will conform to manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 3.1.1.1, Servicing the Power Train of the M715, 1 1/4 ton Cargo Truck.

Topic 3.1.4 SERVICING THE M715 1 1/4 TON CARGO TRUCK Contact Hours: 8

Enabling Objectives: Upon completion of this topic each student will be able to perform service procedures to the M715, 1 1/4 ton cargo truck. Specifically, he will locate service points, dispense appropriate lubricant, and check fluid levels while using appropriate handtools, lubrication equipment and lubrication orders. All performance will meet manufacturer's specifications as specified in the Job Sheet CM "A" JS 3.1.1.1, Servicing the M715 1 1/4 Ton Cargo Truck.

UNIT 4.1 CRAWLER TRACTOR POWER TRAIN MAINTENANCE Contact Hours: 52

Terminal Objective: Upon completion of this unit each student will be able to: (1) Service the power train and chassis units of the Caterpillar D4D Crawler tractor. Using appropriate handtools, special tools, shop equipment and oxy-mapp gas outfit, he will remove, disassemble, inspect and replace worn parts, assemble and adjust the master clutch, transmission, steering clutches, final drive/sprocket assembly, bevel gear assembly and track roller frame assembly. All tasks will meet manufacturer's specifications without deviation as specified in Job Sheets CM "A" JS 4.1.1.1, Oxy-mapp Gas Heating and Cutting and CM "A" JS 4.1.2.1, Servicing the D4D Caterpillar Crawler Tractor Power Train, and (2) Adjust the International model 260 Cable Control unit using appropriate handtools ans shop equipment. All adjustments will conform without deviation to manufacturer's specifications as specified in the Job Sheet CM "A" JS 4.1.3.1, Adjusting International Model 260 Cable Control Units.

Topic 4.1.1 OXY-MAPP GAS HEATING AND CUTTING Contact Hours: 6

Enabling Objectives: Upon completion of this topic each student will be able to safely set up, operate and secure oxy-mapp gas welding outfit to accomplish a heating and cutting operation as specified in the Job Sheet CM "A" JS 4.1.1.1, Oxy-Mapp Gas Heating and Cutting, without deviation.

22

Topic 4.1.2 CONSTRUCTION EQUIPMENT POWER TRAINS Contact Hours: 42

Enabling Objectives: Upon completion of this topic each student will be able to service the power train and chassis units of the Caterpillar D4D Crawler Tractor while using appropriate handtools, special tools, shop equipment and materials. Specifically, he will remove, disassemble, inspect, replace worn parts, assemble, lubricate and adjust the master clutch, transmission, steering clutches, final drive/sprocket, bevel gear assembly and track roller frame assembly. All tasks will meet manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 4.1.2.1, Servicing the D4D Caterpillar Crawler Tractor Power Train.

Topic 4.1.3 ADJUSTMENT OF INTERNATIONAL MODEL 260 CABLE CONTROL UNIT Contact Hours: 4

Enabling Objectives: Upon completion of this topic each student will be able to adjust the International Model 260 Cable Control Unit using appropriate handtools and shop equipment. All adjustments will conform to manufacturer's specifications without deviation as specified in the Job Sheet CM "A" JS 4.1.3.1, Adjusting the International Model 260 Cable Control Unit.

ANNEX I

TEXTS

1. Aneroids, Cummins, Bulletin No. 985605-R, Cummins Engine Co. Inc., Columbus, Indiana 47201.

2. Automotive Mechanics 6th Edition, McGraw-Hill Book Co.

3. Automotive Electrical Equipment, Seventh Edition, McGraw-Hill Book Co.

4. Construction Mechanic 3 & 2, NAVPERS 10644-F.

5. Cummins Diesel Engines, Construction, Industrial, Industrial Fire Pump, Logging, Mining, Railway, Generator, Operation and Maintenance Manual, Bulletin No. 983711-OE, Cummins Engine Co. Inc., Columbus Indiana 47201.

6. Cummins Tune-up and Trouble-Shooting, Bulletin No. 983643-CE, Cummins Engine Co. Inc., Columbus, Indiana 47201.

7. Detroit Diesel Field Service Data (Military) Form 18SZ51, Detroit Diesel Engine Division, General Motors Corp., Detroit Michigan 48228.

8. Diesel the Modern Power, Fourth Edition, Sixth Printing, General Motors Corp., Detroit Michigan 48228.

9. Direct Support, General Support and Depot Maintenance for Engine Diesel (Multifuel) Turbocharged, Fuel Injected, Water Cooled, 6-cylinder (LDS465-1) and (LD465-1), TM9-2815-210-35.

10. Fluid Power, NAVPERS 16193-B.

11. Get a Clear Picture of Your Turbocharger and -----Form FE035934, Caterpillar Tractor Co., Peoria, Illinois 61602.

12. In-Line 71 Series Detroit Diesel Maintenance, Form 6SE177, Detroit Diesel Engine Division, GM Corp., Detroit, Michigan 48228.

13. Organizational Maintenance Manual for Truck, Cargo, 1 1/4 Ton, 4 x 4, M715, TM9-2320-244-20.

14. Operator's Manual International UDT 429 Engine and Attachments, Form 1-085-250-R1, International Harvester Co., 401 North Michigan Avenue, Chicago, Illinois 60611.

15. Operation and Adjustment, P.T. Fuel System, Bulletin No. 983438-A, Cummins Engine Co. Inc., Columbus, Indiana 47201.

16. Operation and Maintenance Instructions, Caterpillar D-4 Tractor, Serial No. 78A1-UP, 86A1-UP, Form 34887-2, Caterpillar Tractor Co., Peoria, Illinois 61602.

17. Operation and Maintenance Instructions, Caterpillar D-333 and D-330 Industrial Engines, Form FE045040-02, Caterpillar Tractor Co., Peoria, Illinois 61602.

18. Operation and Maintenance Instructions, Caterpillar D-342 Engine, Form FE31603-9, Caterpillar Tractor Co., Peoria, Illinois 61602.

19. Organizational Direct Support and General Support Maintenance for Model M-715, 1 1/4 Ton, 4 x 4 Cargo Truck TM9-2320-244-34.

20. Organizational Direct Support and General Support, Repair Parts and Special Tool List for Truck, Cargo, 1 1/4 Ton, 4 x 4 M-715, TM9-2320-244-34P.

21. Service Manual for Caterpillar D-4 Tractor, Serial No. 78A1-UP, Caterpillar Tractor Co., Peoria, Illinois 61602.

22. Service Manual International Cable Control Units Form ISS-1513, International Harvester Co., 401 North Michigan Avenue, Chicago, Illinois 60611.

23. Service Manual International 429 Series Diesel Engine, Form ISS1530D, International Harvester Co., 401 North Michigan Avenue, Chicago, Illinois 60611.

24. Service Manual Roosa Master Fuel Injection Pump for International Diesel Engines, Form ISS1042D, International and Hough Construction Equipment, 401 North Michigan Avenue, Chicago, Illinois 60611.

25. Service Training Outline, Cable Control Units, Models 260, 270 and 280, Melrose Tech. Course TE-4, International Harvester Construction Equipment Division, 401 North Michigan Avenue, Chicago, Illinois 60611.

26. The Principles of a Mechanical Governor, Bulletin 983601, Cummins Engine Co.Inc., Columbus, Indiana 47201.

27. V-71 Engines, Detroit Diesel Operator's Manual, Form 6SE215 (Current Series), Detroit Diesel Engine, Division, GM Corp., Detroit, Michigan 48228.

28. Steelworker 3 & 2, NAVPERS 10653-F.

29. 1969 Ford Truck Shop Manual, Vol. Three, Ford Service Publications, Ford Motor Co., Dearborn, Michigan 48207.

30. 1969 Ford Truck Shop Manual, Vol. Two, Ford Service Publicationa, Ford Motor Co., Dearborn, Michigan 48207.

ANNEX II

REFERENCES

1. Department of the Navy Safety Precautions for Shore Activities, NAVSO P-2455 (Current Series).

2. How to Study, TF Staton, McQuiddy Printing Co., Nashville, Tennessee.

3. Management of Transportation Equipment, NAVFAC P-300.

4. NAVCONSTRACENINST 5400.4 (Current Series) (Organizational Manual of NAVCONSTRACEN).

5. Oxyacetylene Handbook, Second Edition, Linde Air Products, Division of Union Carbide, 270 Park Avenue, New York, New York 10017.

6. Construction Battalion Administration, NAVFAC P-315.

7. Direct Support, General Support and Depot Maintenance, (including repair parts and special tools) for Pump, Fuel Metering and Distributing Assembly (American Bosch PSB6A) TM9-2910-226-35.

ANNEX III

TOOLS, EQUIPMENT AND MATERIALS

FSN/MFG. NO.	ITEM	QTY	COST
TOOLS			
55719-VEV-1022-K-B	Automotive Handtools w/cabinet	24 ea.	374.53
	Automotive Shop Tools		
	Battery Shop Tools		
9HE 4910-00-273-3658	Brake Fluid Dispensers	6 ea.	40.13
	Caterpillar Crawler Tractor Tools		
9QZ 5180-oo-592-7141	Caterpillar Diesel Engine Special Tools	3 ea.	295.12
9QL 5180-00-297-8908	Cummins Diesel Engine Special Tools	6 ea.	209.93
	Diesel Engine Handtools		
	Diesel Engine Shop Tools		
	GM Diesel Engine Special Tools		
9CD 4930-00-253-2478	Grease Guns	12 ea.	2.47
	Heavy Equipment Handtools		
	Heavy Equipment Shop Tools and Equipment		
	International Diesel Engine Special Tools		
9GQ 7240-00-255-5996	Lubricating Oil Dispensers	6 ea.	5.56
	Measuring Instruments		
	Tire Shop Tools		
	Welding Shop Handtools	4 sets	
9QG 5180-00-932-5345	Tool Kit Brake Service	6 ea.	47.90

FSN/MFG. NO.	ITEM	QTY	COST
EQUIPMENT (MAJOR)			
	Caterpillar D4D Crawler Tractor	6 ea.	
	Caterpillar D3306 Diesel Engine	3 ea.	
	Caterpillar D342 Diesel Engine	3 ea.	9,200.00
	Cummins NH250 Diesel Engine	6 ea.	
	Cummins PT Fuel Injection Pump	12 ea.	
	Ford 240 CI 6 Cyl Gasoline Engine	12 ea.	
	GM V6-71 Diesel Engine	6 ea.	6,000.00
	GM 6-71 Diesel Engine	6 ea.	
	IHC UDT 429 Diesel Engine	4 ea.	
	IHC Model 260 Power Control Unit	4 ea.	
	LD 465-1 Multifuel Engine	4 ea.	
2GD 2320-00-246-4077	M715 1 1/4 Ton Cargo Truck	12 ea.	8,030.00
9GD 3433-00-076-3261	Oxy-Mapp Gas Cutting Outfit	4 ea.	345.00
2CZ 4930-00-236-0806	Portable Lubrication Unit	1 ea.	6,080.00
2CZ 4940-00-841-9317	Portable Steam Cleaner	1 ea.	2,010.00
95564/20-20	Tire Demounter	2 ea.	423.00
2CD 2320-00-926-0873	2 1/2 Ton M Series 6 x 6 Truck	2 ea.	8,270.00
	5 Ton M Series 6 x 6 Truck	2 ea.	
EQUIPMENT (TEST)			
9LD 6630-00-171-5157	Battery Hydrometer	12 ea.	1.78
70L 4910-00-199-8080	Battery Starter Testers	6 ea.	100.00
1HL 4910-00-241-3081	Compression Tester	12 ea.	19.50
1HC 4910-00-906-0410	Cooling System Pressure Tester	12 ea.	13.00

FSN/MFG. NO.	ITEM	QTY	COST
EQUIPMENT (TEST) (CONT'd)			
9VD 4910-00-199-8125	Tach-Dwell Meter	12 ea.	95.00
9HE 4910-00-937-5724	Timing Light	12 ea.	35.48
9H 4910-00-255-8673	Vacuum Gauge	12 ea.	12.42
MATERIALS (CONSUMABLE)			
	Gasoline and Diesel Engine Parts		
	Batteries		
	Brake System Parts Kit		
	Caterpillar Fuel Filters		
	Caterpillar Air Filters		
	Caterpillar Oil Filters		
	Charging System Components		
9GD 9150-00-057-8977	Chassis Grease		24.90 dr.
9GK 6850-00-285-8012	Cleaning Solvent		20.50 dr.
9AD 2640-00-273-1625	Cold and Hot Patch, Kit		22.24 ea.
	Cranking System Components		
	Cummins Air Filters		
	Cummins Fuel Filters		
	Cummins Oil Filters		
9XO 9140-00-286-5297	Diesel Fuel (Drummed) DF2		8.97 dr.
9GK 9150-00-189-6729	I.C.E. Engine Oil HDO 30		37.10 dr.
9GD 6810-00-297-9540	Distilled Water (5 Gal. Cont.)		3.13 bt.
9GD 4240-00-202-9473	Face Shields		2.09 ea.
	Ford Engine Gasket Sets		
9XO 9130-00-240-8204	Gasoline (Drummed)		12.10 dr.

FSN/MFG. NO.	ITEM	QTY	COST
MATERIALS (CONSUMABLE)	(CONT'D)		
9GZ 9150-00-577-5846	Gear Oil EP 90		42.20 dr.
	GM Diesel Air Filters		
	GM Diesel Fuel Filters		
	GM Diesel Oil Filters		
9GD 9150-00-231-9071	Hydraulic Brake Fluid		2.18 gal.
9QZ 5120-00-965-0326	Igniters, Torch		.21 ea.
9QG 5120-00-965-0603	Flint, Igniters		.18 bx.
	Ignition System Components		
	International Air Filters		
	International Fuel Filters		
	International Oil Filters		
9GL 6830-00-935-1125	Mapp Gas (Bulk)		.30 lb.
9GD 8120-00-350-5477	Cylinder, Mapp Gas	4 ea.	20.00
	Multifuel Engine Air Filters		
	Multifuel Engine Oil Filters		
	Multifuel Engine Fuel Filters		
9GL 6830-00-169-0805	Oxygen (Welding)		.01 cu. ft.
9GD 8120-00-151-9758	Cylinder Oxygen	4 ea.	25.00 ea.
	Sheet Metal (Scrap)		
7030-269-1272	Sweeping Compound, Oil and Water		1.40 bg.
	Tires		
	Tubes		
9AH 2640-922-6921	Tubeless Tire Repair Kits		36.03
9DD 8415-268-7860	Welding Gloves	8 ea.	3.72 pr.

FSN/MFG. NO.	ITEM	QTY	COST
MATERIALS (CONSUMABLE)	(CONT'D)		
9DD 8415-00-250-2531	Apron, Welding	8 ea.	10.00 ea.
9GD 4240-00-203-3804	Welding Goggles (Lens Shade 6)	8 ea.	1.25 ea.
9CD 4720-00-834-2560	Welding Hose	4 ea.	27.80 ea.
9GC 3439-00-270-6047	Welding Tip Cleaner	4 ea.	1.46 ea.
9GD 3433-00-076-3261	Torch Outfit, Cutting And Welding	4 ea.	345.00 ea.
9GD 3920-00-802-8313	Cart, Cutting and Welding Outfit	4 ea.	72.00 ea.
	Welding Tips		
9QG 7920-00-401-8034	Wiping Rags		2.45 bd.
5210-00-640-6177	Plastigage .001 - .003		

ANNEX IV

TRAINING AIDS AND DEVICES

FILMS

1.	MA1672Q	Automotive Trouble-Shooting, Part 15, The Clutch (21 min.) Obsolete.
2.	MN1730A	Elementary Hydraulics, Part I, Derivation of Pascal's Law (16 min.).
3.	MN1730C	Elementary Hydraulics, Part I, Application of Pascal's Law (12 min.).
4.	MN1730E	Elementary Hydraulics, Liquids in Motion (13 min.).
5.	MN1921G	Safety for Welders (17 min.).
6.	MA3739	Automotive Gears, Principles of Operation (25 min.) obsolete.
7.	MC7889	The Tools and Rules for Precision Measuring (30 min.).
8.	MN8016A	Basic Electricity, The Electron Theory (5 min.).
9.	MN8016B	Basic Electricity, How Magnets Produce Electricity (3 min.).
10.	MA8070	Planetary Gears, Principles of Operation, Part I, Single Sets (18 min.).
11.	MC8146	The Gamblers (20 min.).
12.	MN8594A	Direct Current Generators, Theory of Operation (16 min.).
13.	MC8622B	Boss of the Bulldozers, Caterpillar Tractor Co., (C 18mm).
14.	MA8886	Carburetor Principles of Operation (25 min.).
15.	MC9172A2	A Matter of Time, Caterpillar Tractor Co., (23 min.).
16.	MN9757	Naval Construction Forces (23 min.) Color.
17.	MV9861	Oxyacetylene Cutting Manual (9 min.).
18.	MH10017	It Can Happen, International Harvester Co. (20 min.) Color.
19.	MC10417	ABC of Diesel Engines (20 min.).
20.	MN8594B	Direct Current Motors, Theory of Operation (10 min.).
21.	MN44A	Diesel Engine Governors, Part 1 (12 min.).

FILMS (Commercial; Non-Navy, Non-Government)

1.	76S	Short Cut, New Tools and Methods, Caterpillar Tractor Co. (C 20 min.).
2.	OE483	Hydraulic Brake Systems.
3.	9051	Boss of the Bulldozer, Caterpillar Tractor Co. (C 20 min.).
4.	985566M	Turbocharger, Cummins Engine.

FILMS (Commercial; TAMARS Numbers Assigned)

1.	ABC-001	ABC Of Handtools, Part 1, GM Corp. (C 18 min.).
2.	ABC-002	ABC of Handtools, Part 3, GM Crop. (C 15 min.).
3.	ABC-003	ABC of Automotive Engines, GM Corp. (21 min.).
4.	CAS-001	The Case of the Slippery Oil, Dana Corp. (C 40 min.).
5.	COO-001	Cooling System, Ethyl Corp. (C 20 Min.).
6.	OPE-001	Operation Hour Glass, Cummins Engine, (C 27 min.).
7.	OPE-010	Operation and Maintenance, Part 1, Bendix-Westinghouse Air Brakes (C 24 min.).
8.	LET-001	Let'er Roll, Timken Roller Bearing Co. (50 min.).
9.	ROL-002	The Roll of Drums, Caterpillar Tractor Co. (20 min.)
10.	POW-009	Power Train (13 min.).

FILMS (Government, Non-Navy)

1.	TF9-3276	Truck Cargo, 2 1/2 Ton, 6 x 6 M35A1 (Multi-Fuel Engine, Introduction and Operation) (13 min.).
2.	TF9-3469	Multi-Fuel Engine Principles, Model LDS472-2 (24 min.).

SLIDE FILMS (Commercial)

1.		American Bosch PSB6A Fuel Pump.
2.	Module 6001 Gasoline Engine, Principles of Operation, Ford Motor Co.	
3.	SC8620C	IHC Cable Control Units.
4.	TE-4	IHC Cable Control Units.
5.	9010K	Introduction to Automotive Electrical Systems, Delco-Remy.

SLIDE FILMS (Commercial) (Cont'd)

6.	9011K	Delcotron Generator and the Charging Circuit, Delco-Remy.
7.	9020K	20,000 Volts Under the Hood, Delco-Remy.
8.	9025K	The Cranking Circuit, Delco-Remy.
9.		Roosa-Master Fuel Injection System, IHC Diesel Engines.
10.		GM 71 Series Diesel Engine Construction.
11.		Multi-Fuel Engine Construction.
12.	Module 4001	Car Rear Axle Principles of Operations, Ford Motor Co.
13.	CT-25	Torque Converter, International Harvester Co. (Set of 56 slides).
14.	CT-26	Power Shift, International Harvester Co. (Set of 80 slides).
15.	JEGO-1104	Truck Type Tractors, Caterpillar Tractor Co. (Set of 65 slides).
16.	JEGO-1106	Sprocket Removal and Installation, Caterpillar Tractor Co. (Set of 50 Slides).
17.	JEGO-1706	Safety and You, Caterpillar Tractor Co. (Set of 19 slides).
18.	JEOO-1601	Direct Drive Transmission, Caterpillar Tractor Co. (Set of 50 slides).
19.	JEOO-1602	Clutches, Part 1, Caterpillar Tractor Co. (Set of 63 slides).
20.	JEOO-1603	Clutches, Part 2, Caterpillar Tractor Co. (Set of 46 slides).
21	JEOO-1604	Power Shift, Caterpillar Tractor Co. (Set of 54 slides).
22.	JEOO-1606	Final Drives, Part 1, Caterpillar Tractor Co. (Set of 43 slides),

SLIDES (Individual)

1. CM "A" S 4.1.2.1, "D-8 Crawler Tractor w/o Blade".
2. CM "A" S 4.1.2.2, "MRS-I-110 Wheeled Tractor w/o Attachments".
3. CM "A" S 4.1.2.3, "IHC Wheeled Tractor w/o Attachments".
4. CM "A" S 4.1.2.4, "D-7 Crawler Tractor with Std. Dozer Blade".

SLIDES (individual) (Cont'd)

5. CM "A" S 4.1.2.5, "D-8 Crawler Tractor with Angle Dozer Blade".
6. CM "A" S 4.1.2.6, "955 Crawler Front End Loader w/std. Bucket".
7. CM "A" S 4.1.2.7, "MRS-S-110 Scraper with MRS-I-110 Tractor".
8. CM "A" S 4.1.2.8, "Galion 118-T, Motor Grader".
9. CM "A" S 4.1.2.9, "3 Axle Road Roller".
10. CM "A" S 4.1.2.10A, "Sheepsfoot Roller (Towed)".
11. CM "A" S 4.1.2.10B, "Wobbly Wheel Roller (Towed)".
12. CM "A" S 4.1.2.10C, "Grid Roller (Towed)".
13. CM "A" S 4.1.2.10D, "Wobbly Wheel Roller (Towed)".
14. CM "A" S 4.1.2.11, "Crawler Mounted Crane".
15. CM "A" S 4.1.2.12, "Truck Mounted Crane".
16. CM "A" S 4.1.2.13, "Wheeled Mounted Crane".
17. CM "A" S 4.1.2.14, "Air Compressor, 600 CFM, Rotary".
18. CM "A" S 4.1.2.15, "Master Clutch Components".
19. CM "A" S 4.1.2.16, "Master Clutch Brake".
20. CM "A" S 4.1.2.17, "Transmission Gear Arrangement".
21. CM "A" S 4.1.2.18, "Transmission Gearshift Mech.".
22. CM "A" S 4.1.2.19a, b, c, d, e, f, "Transmission Interlock".
23. CM "A" S 4.1.2.20, "Steering Clutch Components".
24. CM "A" S 4.1.2.21, "Steering Clutch Brake Mechanism".
25. CM "A" S 4.1.2.22, "Steering Clutch Exposed View".
26. CM "A" S 4.1.2.23, "Steering Clutch Assembly Check".
27. CM "A" S 4.1.2.24, "Final Drive Operation".
28. CM "A" S 4.1.2.25, "Final Drive and Cover Assembly".

SLIDES (Individual) (Cont'd)

29. CM "A" S 4.1.2.26, "Track and Roller Frame Group".
30. CM "A" S 4.1.2.27, "Track and Roller Frame Link and Pins".
31. CM "A" S 4.1.2.28, "Track and Roller Frame Pins and Links".
32. CM "A" S 4.1.2.29a, b, "Track and Roller Frame Link and Pins".
33. CM "A" S 4.1.2.30a, b, "Track Shoes (Types)".
34. CM "A" S 4.1.2.31, "Track Adjustments".
35. CM "A" S 4.1.2.32, "Track Roller Lubrication".
36. CM "A" S 4.1.2.33, "Track Recoil Mechanism".
37. CM "A" S 4.1.2.34, "Track Frame Alignment".

TRANSPARENCIES

1. Module 7001 Car 3-speed Manual Shift Transmission and Overdrive Principles of Operation, Ford Motor Co.
2. Module 7001 Car and Truck Clutches, Principles of Operation, Ford Motor Co.

CHARTS (Commercial)

1. Section "A" Fundamentals of Electricity and Magnetism, Delco-Remy.
2. Section "B" Energizers and Batteries, Delco-Remy.
3. Section "C" Cranking Motors, Delco-Remy.
4. Section "D" Ignition System, Delco-Remy.
5. Section "E" Generators - D.C. Type, Delco-Remy.
6. Section "K" Fundamentals of Delcotron Generators - A.C. Type, Delco Remy.
7. Engine Cooling System, End View, Cummins Engine Co.
8. Engine Cooling System, Side View, Cummins Engine Co.

CHARTS (Commercial) (Cont'd)

9.		Engine Lubricating System, End View, Cummins Engine Co.
10.		Engine Lubricating System, Side View, Cummins Engine Co.
11.	Module 4200	Car Rear Axle Diagnosis, Ford Motor Co.
12.	Module 6002	Gasoline Engine Diagnosis, Ford Motor Co.
13.	Module 7002	Car and Truck Clutches, Diagnosis and Adjustment, Ford Motor Co.
14.	Module 7203	Truck 4 and 5 speed Manual Transmission, Principles of Operations, Ford Motor Co.
15.		P. T. Fuel System Operation, Cummins Engine Co.
16.		P. T. Fuel System Flow, Cummins Engine Co.

LOCALLY PREPARED MATERIALS

INFORMATION SHEETS

1. CM "A" IS 1.1.2.1 "Study Techniques".
2. CM "A" IS 1.1.3.1 "Safety Policies".
3. CM "A" IS 1.2.2.1 "Maintenance Of Lead Acid Storage Batteries".
4. CM "A" IS 1.2.2.2 "Basic Principles of Electricity".
5. CM "A" IS 1.2.2.3 "Electrical Circuits".
6. CM "A" IS 1.2.3.1 "General Housekeeping".
7. CM "A" IS 1.2.4.1 "Measuring Instruments".
8. CM "A" IS 1.2.4.2 "Fractions".
9. CM "A" IS 1.2.4.3 "Conversion Chart".
10. CM "A" IS 2.1.1.1 "Magnetos".
11. CM "A" IS 3.1.1.1 "The Power Train of the M715 1 1/4 Ton Cargo Truck".

JOB SHEETS

1. CM "A" JS 1.2.3.1 "Gasoline Engine Disassembly, Inspection and Assembly".
2. CM "A" JS 1.2.6.1 "Gasoline Engine Diagnosis and Adjustment".
3. CM "A" JS 2.1.1.1 "Maintenance of Caterpillar Diesel Engines".
4. CM "A" JS 2.2.1.1 "Maintenance of IHC UDT 429 Engines".
5. CM "A" JS 2.3.1.1 "Maintenance of General Motors Diesel Engines".
6. CM "A" JS 2.4.1.1 "Maintenance of Cummins NH Diesel Engines".
7. CM "A" JS 2.5.1.1 "Maintenance of LD 465-1 Multifuel Engines".
8. CM "A" JS 3.1.1.1 "Servicing the Power Train of the M715 1 1/4 Ton Cargo Truck".
9. CM "A" JS 4.1.1.1 "Oxy-Mapp Gas Heating and Cutting".
10. CM "A" JS 4.1.2.1 "Servicing the D4D Crawler Tractor".
11. CM "A" JS 4.1.3.1 "Adjusting the IHC Model 260 Power Control Unit".

WORK SHEETS

1. CM "A" WS 1.2.4.1 "Mathematics Work Sheet".

PROBLEM SHEETS

1. CM "A" PS 3.1.1.1 "Suspension Field Test (Series)".
2. CM "A" PS 3.1.2.1 "Power Train Field Test (Series)".
3. CM "A" PS 3.1.3.1 "Brake Service Field Test (Series)".

ANNEX V

TRAINING AIDS EQUIPMENT

DEVICES

1.	NP-17008	Device 6A2 Engine Internal Combustion, Electrically Operated, $9195.00
2.		Projectors, 16mm sound.

DEVICES (Non-Navy)

1.	D-315	Caterpillar Diesel Engine (Cutaway) $8700.00.
2.	GM 3-71	Diesel Engine (Cutaway).
3.	Cummins	P. T. Pump (Cutaway).
4.	American Bosch	Model PSB6A Fuel Injection Pump (Cutaway).
5.	American Bosch	Manual 5 speed Transmission (Cutaway).
6.	American Bosch	Differential Assembly, Double Reduction (Cutaway).
7.	American Bosch	Air Brake System (mounted onboard) $2445.00
8.	International	Model 260 Cable Control Unit (Cutaway).
9.	Roosa-Master	Fuel Injection Pump (Cutaway).
10.	Caterpillar	Turbocharger (Cutaway).
11.		35mm projectors, tape recorders.

ANNEX VI

FORMS

1. Equipment Work Order (NAVFAC 6-11200/41 Rev. 5-69) 0105-002-5326.
2. Shop Repair Order (continuation sheet) (NAVFAC 9-11200/3B (9-67)) 0105-004-1020.

ANNEX VII

MASTER SCHEDULE

FIRST WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
1.0.0	C	1	Base & Command Indoctrination	24/1
		2		
1.0.1	C	3	Chaplain Lecture	24/1
1.0.2	C	4	Military Courtesies, Uniforms & Grooming Standards	24/1
1.1.1	C	5	School Indoctrination	24/1
1.1.2	C	6	Study Techniques	24/1
1.1.3	C	7	Safety Policies	24/1
SECOND DAY				
1.2.1	C	8	Internal Combustion Engine Principles	24/1
		9		
		10		
		11		
		12		
		13		
		14.0		
1.0.3	F	14.5	Aerobics	24/1
THIRD DAY				
1.2.1	C	15	Internal Combustion Engine Principles	24/1
		16		
		17		
		18.0		
	S	18.5		6/1
		19		
		20		
		21.0		
	F	21.5	Aerobics	24/1
FOURTH DAY				
1.2.1	S	22	Internal Combustion Engine Principles	6/1
		23		
	C	24		24/1
		25		
		26		
		27		
		28		

FIRST WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH DAY				
1.2.3	C	29	Gasoline Engine Disassembly	24/1
		30		
		31		
1.0.5	C	32	UCMJ	24/1
		33		
1.0.12	C	34	Sea Power	24/1
		35.0		
1.0.3	F	35.5	Aerobics	24/1
SECOND WEEK				
FIRST DAY				
1.2.3	S	1	Gasoline Engine Disassembly	6/1
		2		
		3		
		4		
		5		
		6		
		7.0		
1.0.3	F	7.5	Aerobics	24/1
SECOND DAY				
1.2.3	S	8.0	Gasoline Engine Disassembly	6/1
	C	8.5		24/1
		9.0		
1.2.4	C	9.5	Inspection and Measuring Engine Components	24/1
		10		
		11		
		12		
		13.0		
	S	13.5		6/1
		14		
THIRD DAY				
1.2.4	S	15	Inspection and Measuring Engine Components	6/1
		16		
		17		
		18		
		19		
		20		
		21.0		
1.0.3	F	21.5	Aerobics	24/1

SECOND WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FOURTH DAY				
1.2.4	S	22	Inspection and Measuring Engine Components	6/1
		23		
	C	24		24/1
1.2.5	C	25	Gasoline Engine Assembly	24/1
	S	26		6/1
		27		
		28		
FIFTH DAY				
1.2.5	S	29	Gasoline Engine Assembly	6/1
		30		
		31		
1.0.6	C	32	Pay and Allowances	24/1
1.0.8	C	33	Drug and Alcohol Abuse	24/1
		34		
		35.0		
1.0.3	F	35.5	Aerobics	24/1

THIRD WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
1.2.5	S	1	Gasoline Engine Assembly	6/1
		2		
	C	3		24/1
1.2.2	C	4	Electrical System Principles	24/1
		5		
		6		
		7.0		
1.0.3	F	7.5	Aerobics	24/1
SECOND DAY				
1.2.2	C	8	Electrical System Principles	24/1
		9		
		10		
		11		
		12		
		13		
		14		

THIRD WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
THIRD DAY				
1.2.2	C	15	Electrical System Principles	24/1
		16		
		17		
		18		
		19		
		20		
		21.0		
1.0.3	F	21.5	Aerobics	24/1
FOURTH DAY				
1.2.2	S	22	Electrical System Principles	6/1
		23		
		24		
		25		
	C	26		24/1
1.2.6	C	27	Gasoline Engine Trouble, Diagnosis and Adjustment	24/1
		28		
FIFTH DAY				
1.2.6	C	29	Gasoline Engine Trouble, Diagnosis and Adjustment	24/1
	S	30		6/1
		31		
1.0.4	C	32	Military Behavior and Conduct Ashore	24/1
		33		
		34		
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1
FOURTH WEEK				
FIRST DAY				
1.2.6	S	1	Gasoline Engine Trouble, Diagnosis and Adjustment	6/1
		2		
		3		
	C	4		24/1
		5		
		6		
	S	7.0		6/1
1.0.3	F	7.5	Aerobics	24/1

FOURTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
SECOND DAY				
1.2.6	S	8	Gasoline Engine Trouble, Diagnosis and Adjustment	6/1
		9		
		10		
		11		
	C	12		24/1
		13		
	S	14		6/1
THIRD DAY				
1.2.6	S	15	Gasoline Engine Trouble, Diagnosis and Adjustment	6/1
		16		
		17		
		18		
		19.0		
	C	19.5		24/1
		20		
		21.0		
1.0.3	F	21.5	Aerobics	24/1
FOURTH DAY				
2.1.1	C	22	Caterpillar Diesel Engine Operation	24/1
		23		
		24		
		25		
	S	26		6/1
		27		
	C	28		24/1
FIFTH DAY				
2.1.2	C	29	Caterpillar Diesel Engine Maintenance	24/1
		30		
	S	31		6/1
1.0.2	C	32	Military Courtesies, Uniforms & Grooming Standards	24/1
1.0.7	C	33	Financial Responsibility	24/1
		34		
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH WEEK				
FIRST DAY				
2.1.2	S	1	Caterpillar Diesel Engine Maintenance	6/1
		2		
		3		
	C	4		24/1
		5		
		6		
	S	7.0		6/1
1.0.3	F	7.5	Aerobics	24/1
SECOND DAY				
2.1.2	S	8	Caterpillar Diesel Engine Maintenance	6/1
		9		
		10		
		11		
	C	12		24/1
		13		
		14		
THIRD DAY				
2.1.2	C	15	Caterpillar Diesel Engine Maintenance	24/1
		16		
	S	17		6/1
		18		
		19		
		20		
		21.0		
1.0.3	F	21.5	Aerobics	24/1
FOURTH DAY				
2.1.2	C	22	Caterpillar Diesel Engine Maintenance	24/1
2.2.1	C	23	International Diesel Engine Operation	24/1
	S	24		6/1
		25		
	C	26		24/1
2.2.2	C	27	International Diesel Engine Maintenance	24/1
		28		

FIFTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH DAY				
2.2.2	C	29	International Diesel Engine Maintenance	24/1
	S	30		6/1
		31		
1.0.9	C	32	Career Opportunities & Special Programs	24/1
		33		
1.0.15	C	34	Security	24/1
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1
SIXTH WEEK				
FIRST DAY				
2.2.2	S	1	International Diesel Engine Maintenance	6/1
		2		
		3		
	C	4		24/1
		5		
		6		
	S	7.0		6/1
1.0.3	F	7.5	Aerobics	24/1
SECOND DAY				
2.2.2	S	8	International Diesel Engine Maintenance	6/1
		9		
		10		
		11		
		12		
	C	13		24/1
	S	14		6/1
THIRD DAY				
2.2.2	C	15	International Diesel Engine Maintenance	24/1
	S	16		6/1
		17		
		18		
	C	19		24/1
	S	20		6/1
		21.0		
1.0.3	F	21.5	Aerobics	24/1

SIXTH WEEK (Cont'd)

FOURTH DAY

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
2.2.2	S	22	International Diesel Engine Maintenance	6/1
		23		
	C	24		24/1
		25		
2.3.1	C	26	General Motors Diesel Engine Operation	24/1
		27		
	S	28		6/1

FIFTH DAY

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
2.3.1	S	29	General Motors Diesel Engine Operation	6/1
	C	30		24/1
		31		
1.0.19	C	32	Enlisted Performance Evaluations	24/1
1.0.14	C	33	Advancement in Rate	24/1
1.0.11	C	34	Navy Human Goals Objective	24/1
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1

SEVENTH WEEK

FIRST DAY

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
2.3.2	C	1	General Motors Diesel Engine Maintenance	24/1
		2		
	S	3		6/1
		4		
	C	5		24/1
		6		
		7.0		
1.0.3	F	7.5	Aerobics	24/1

SECOND DAY

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
2.3.2	C	8	General Motors Diesel Engine Maintenance	24/1
	S	9		6/1
		10		
		11		
		12		
	C	13		24/1
		14		

SEVENTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
THIRD DAY				
2.3.2	S	15	General Motors Diesel Engine Maintenance	6/1
		16		
		17		
		18		
		19		
		20		
	C	21.0		24/1
1.0.3	F	21.5	Aerobics	24/1
FOURTH DAY				
2.3.2	S	22	General Motors Diesel Engine Maintenance	6/1
		23		
		24		
		25		
	C	26		24/1
		27		
2.4.1	C	28	Cummins Diesel Engine Operation	24/1
FIFTH DAY				
2.4.1	S	29	Cummins Diesel Engine Operation	6/1
		30		
	C	31		24/1
1.0.10	C	32	Basic Principles of Leadership	24/1
1.0.13	C	33	Safe Driving	24/1
1.0.18	C	34	CHAMPUS - Medical Care	24/1
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1
EIGHTH WEEK				
FIRST DAY				
2.4.2	C	1	Cummins Diesel Engine Maintenance	24/1
		2		
	S	3		6/1
		4		
	C	5		24/1
		6		
	S	7.0		6/1
1.0.3	F	7.5	Aerobics	24/1

EIGHTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
SECOND DAY				
2.4.2	S	8	Cummins Diesel Engine Maintenance	6/1
		9		
		10		
		11		
		12		
	C	13		24/1
	S	14		6/1
THIRD DAY				
2.4.2	S	15	Cummins Diesel Engine Maintenance	6/1
	C	16		24/1
		17		
	S	18		6/1
		19		
		20		
		21.0		
1.0.3	F	21.5	Aerobics	24/1
FOURTH DAY				
2.4.2	C	22	Cummins Diesel Engine Maintenance	24/1
2.5.1	C	23	LD 465-1, Multi-Fuel Engine Operation	24/1
		24		
	S	25		6/1
		26		
	C	27		24/1
2.5.2	C	28	LD 465-1, Multi-Fuel Engine Maintenance	24/1
FIFTH DAY				
2.5.2	C	29	LD 465-1, Multi-Fuel Engine Maintenance	24/1
	S	30		6/1
		31		
1.0.16	C	32	Navy Traditions and Customs	24/1
1.0.20	C	33	Educational Opportunities	24/1
1.0.35	C	34	Nature Makes Some Traffic Laws	24/1
1.0.17	F	35.0	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	24/1

NINTH WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
2.5.2	S	1	LD 465-1, Multi-Fuel Engine Maintenance	6/1
		2		
	C	3		24/1
	S	4		6/1
	C	5		24/1
	S	6		6/1
	C	7.0		24/1
1.0.3	F	7.5	Aerobics	24/1
SECOND DAY				
2.5.2	C	8	LD 465-1, Multi-Fuel Engine Maintenance	24/1
	S	9		6/1
		10		
		11		
	C	12		24/1
	S	13		6/1
		14		
THIRD DAY				
2.5.2	S	15	LD 465-1, Multi-Fuel Engine Maintenance	6/1
		16		
		17		
		18		
	C	19		24/1
		20.0		

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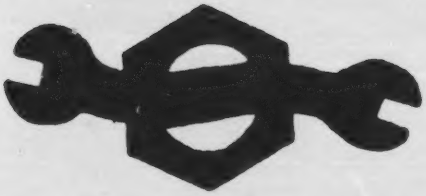
CONSTRUCTION MECHANIC SCHOOL

CLASS "A"

INSTRUCTOR GUIDES

PHASE 1



Gasoline Engine Repair and Adjustment

MODIFICATIONS

Instructor Guide of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Study Techniques

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts: None.

B. References:

1. How to Study, T. F. Staton, McQuiddy Printing Co., Nashville, Tennessee.

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices:

1. Locally Prepared Materials:

a. Information sheets.

(1) CM "A" IS 1.1.2.1, "Study Techniques".

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit each student will have registered for the course, received course textbooks, answered questions pertaining to key points on the organization, mission and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, met his counselor, stated the standards of the school, described the benefits that can be derived from good study techniques, listed the factors contributing to the enhancement of good study techniques, stated how to report accidents or fires and listed the safety practices that will be enforced in the school.

Enabling Objectives: Upon completion of this topic each student will have described the benefits that may be derived from good study techniques and stated the factors contributing to the enhancement of good study techniques.

Criterion Test: Describe the benefits that may be derived from good study techniques and state the factors contributing to the enhancement of good study techniques.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Study Techniques.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better mechanic.		
D. Overview.	I.D. State learning objectives.	
1. Ask questions.	1. State information and materials necessary to guide student.	
II. Presentation.		
A. Steps of procedure.		
1. Benefits of good study techniques.		
a. Economy of time and effort.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

b. Study techniques.

  (1) Attitude.

  (2) Study environment.

  (3) Time budgeting.

  (4) Concentration habits.

  (5) Reading habits.

  (6) Note taking.

2. Factors contributing to good study techniques.

  a. Favorable environment.

    (1) Free from distraction.

    (2) Proper lighting.

    (3) Proper temperature.

    (4) Comfortable furniture.

    (5) Necessary materials on hand.

  b. Study time budget.

    (1) Definite study time.

    (2) Daily load of study hours.

    (3) Avoid interruptions.

3. Improve reading ability.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Develop reading habit.		
b. Develop better vocabulary.		
III. Application.		
A. Clear up any questions or doubts with students.	III.A. Encourage student questions.	III.A. Ask questions as necessary.
IV. Summary.		
A. Benefits of good study techniques.		
1. Economy of time and effort.		
2. Study techniques.		
B. Factors contributing to good study techniques.		
1. Favorable environment.		
2. Study time budget.		
C. Reading ability.		
1. Develop reading habits.		
2. Develop vocabulary.		
V. Test: None.		

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NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Safety Policies

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts: None.

B. References:

1. Department of the Navy Safety Precautions for Shore Activities, NAVSO P-2455 (Current Series).

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices:

1. Locally Prepared Materials:

a. Information sheets.

(1) CM "A" IS 1.1.3.1, "Safety Policies".

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit each student will have registered for the course, received course textbooks, answered questions pertaining to key points on the organization, mission and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, met his counselor, stated the standards of the school, described the benefits that can be derived from good study techniques, listed the factors contributing to the enhancement of good study techniques, stated how to report accidents or fires and listed the safety practices that will be enforced in the school.

Enabling Objectives: Upon completion of this topic each student will be able to properly report fires and accidents and explain the safety practices that will be enforced in this school.

Criterion Test: State the procedure for properly reporting fires and accidents and explain safety practices that will be enforced in this school.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Safety Policies.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview.	I.D. State learning objectives. 1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION

II. Presentation.

  A. Safety Policies.

    1. Safe handling and use of equipment.

      a. Electrical.

        (1) Good ground connection.

        (2) Use proper cord, one capable of carrying enough current to operate the device you are operating.

        (3) Use power tools within their rated capacity.

      b. Fuels.

        (1) Keep in closed well marked containers (safety cans).

        (2) Store in area well away from open flames or operating equipment.

    2. Safe handling and use of materials.

      a. Proper lifting equipment.

        (1) Use lifting equipment for heavy loads - hoists, jacks, chain falls, etc.

INSTRUCTOR ACTIVITY

II. Issue study guide.

Encourage students to ask questions.

STUDENT ACTIVITY

II. Refer to study guide and take notes during instructor lecture.

b. Proper moving equipment.

(1) Dollies, trucks, etc.

3. Personal safety indoors and out.

a. Tripping hazards.

(1) Door sills.

(2) Miscellaneous low equipment etc.

b. Slipping hazards.

(1) Grease, oil, etc.

c. Eye hazards.

(1) Welding.

(2) Flying particles when grinding, hammering, etc.

(3) Mixing electrolyte.

d. Acids (sulfuric).

(1) Always pour acid into water.

(2) Wear protective clothing.

e. Toxic fumes.

(1) Keep spaces well ventilated.

f. Compressed air.

(1) Never play with air hose, practical jokes with an air nozzle can cause instant death or painful injuries.

(2) Keep nozzle pointed down away from eyes.

4. Avoiding and eliminating fire hazards.

a. Cleanliness.

(1) Keep floors, benches, etc. clean.

b. Proper stowage of material.

(1) Keep gasoline in closed gas cans.

(2) Use waste rag containers.

(a) Never leave dirty or oily rags loose.

5. Methods of reporting accidents and fires.

a. Reporting procedures.

(1) Must be reported to the instructor even though no personal injury is incurred.

(2) Cause must be determined.

(a) To prevent reoccurance of similar accidents.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Corrective action.		
(1) First aid as required.		
(2) Fighting fires as required.		
(a) Know the fire bill.		
(b) Know location of fire extinguishers and alarms.		
6. Introduction of Class Safety Man.		
a. Duties of the Class Safety Man.	II.A.6.a. Point out and stress duties and responsibilities.	II.A.6.a. Safety Man take notes.
(1) Student member shall wear Green Cross Safety Badge on cap for identification.		
(2) Ensure that all personnel in their charge are instructed regarding safe work practice and that all rules and regulations are followed.		
(3) Promote safety consciousness and accident prevention.		
(4) Report immediately to the CPO in Charge any safety hazard or violation, and suggest possible means of correction, where possible. Hazards or violations noted, regardless of location, are to be reported; however, emphasis is to be placed on the detection of safety hazards or violations within their respective school.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Have student state the procedure for properly reporting accidents and fires.	III.A. Call on student by name to state procedures for properly reporting accidents or fires.	
IV. Summary.		
A. Safety policies.		
1. Safe handling and use of equipment.		
2. Safe handling of materials.		
3. Personal safety.		
4. Avoiding and eliminating fire hazards.		
5. Methods of reporting accidents and fires.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Internal Combustion Engine Principles

Average Time: 15 Periods (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., Chapters 3 - 12.

B. References: None.

C. Tools, Equipment and Materials:

1. Ford 6 cylinder gasoline engine (12 ea.).
2. Assorted engine parts.

D. Training Aids and Devices:

1. Films.
    a. ABC-003, "ABC of Automotive Engines", GM Corp. (21 min.).
    b. MA-8886, "Carburetor Principles of Operation", (25 min.).
    c. COO-001, "Cooling System", Ethyl Corp. (20 min.).

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune, and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job sheets CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly" and CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment". Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of 37° - 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Enabling Objectives: Upon completion of this topic each student will be able to identify and select with 100% accuracy all engine parts while considering principles of operation of an internal combustion engine. He will be evaluated on a continuing basis throughout the engine disassembly, measuring and inspection of parts and reassembly sections of CM "A" JS 1.2.3.1.

Criterion Test: Students will answer successfully, 20 of 25 multiple choice test items involving internal combustion engine principles.

Homework: Read, Automotive Mechanics, 6th edition, pp. 55 - 199.

2. Devices.

   a. NP-17008, Device 6A2 Engine Internal Combustion, Electrically Operated.

3. Slide Films.

   a. Gasoline Engines, Principles of Operation Module 6001, Ford Service Publications, P.O. Box 7750, Detroit, Michigan 48207.

4. Locally Prepared Material:

   a. Information sheet.

      (1) CM "A" IS 1.2.1.1, "Internal Combustion Engine Principles".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Internal Combustion Engine Principles		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives. 1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Internal Combustion Engine Principles.	II.A. Issue Information sheet CM "A" IS 1.2.1.1.	II.A. Follow instructor discussion using information sheet.
1. Internal combustion engine. a. An engine in which the combustion (burning) of fuel takes place within the engine cylinder, as opposed to external combustion engine, (steam engine), in which the burning of fuel takes place in the boiler outside the engine cylinder.	II.A.1. Using cutaway engine and training slides, explain meaning of technical words and phrases, basic component and mechanical principles.	II.A.2. Follow instru tor and take notes.
2. Reciprocating engine. a. An engine in which power is developed by the up and down motion of the piston. This is opposed to a rotary engine (gas turbine), in which power is developed entirely from rotary motion.		
3. Cycle. a. A series of events that occur and re-occur in a definite sequence. In a four stroke cycle engine, the four strokes must occur: intake, compression, power and exhaust.		
B. Basic components and mechanical principles:		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

1. Cylinder and piston.

    a. The burning fuel - air mixture is trapped in the cylinder between the cylinder head and piston crown. Expansion of the burning gases forces the piston downward transmitting power to the connecting rod.

2. Connecting rod and crankshaft.

    a. The connecting rod changes the reciprocating motion of the piston to the rotary motion of the crankshaft.

3. Valves and operating mechanism.

    a. Intake valves - permit air and fuel mixture to enter cylinder during the intake stroke.

    b. Exhaust valves - permit the exhaust gases to escape during the exhaust stroke.

    c. Opening and closing of the exhaust and intake valves is accomplished by action of the camshaft through suitable linkage.

C. Engine operation.

1. Intake stroke.

    a. The piston moves down from T.D.C. creating a vacuum in the cylinder.

The intake valve is open, so the mixture of gasoline and air rushes through the opening, pushed by atmospheric pressure outside.

2. Compression stroke.

   a. From its bottom position, bottom dead center (B.D.C.) the piston moves upward. The intake valve closes and the mixture is compressed in the closed end of the cylinder. It is compressed or squeezed to a pressure of perhaps 200 pounds per square inch (PSI).

3. Power stroke.

   a. The spark occurs, the burning mixture expands and almost immediately the pressure jumps to 600 to 700 PSI three or four times the pressure before ignition. With a piston 3 1/2" in diameter, the total pressure on the top will be about three (3) tons. This enormous force pushes the piston down, which of course makes the crankshaft turn, delivering power to whatever is connected to the shaft.

4. Exhaust stroke.

   a. Both valves have been closed during the compression and power strokes, but now the exhaust valve opens. As the piston moves up again it forces the exhaust gases out through the passage opened by the exhaust valve. As the piston gets to the top, the exhaust

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
valve closes and the intake valve opens again, ready for the beginning of the next cycle.	NOTE: Maintain student interest through oral questions: a. Define an internal combustion engine. b. Name the four strokes of four stroke cycle. c. On what stroke does the spark occur?	
D. Engine types:	II.D. Show movie ABC-003, ABC of Automobile Engines (21 min.).	II.D. View movie and take notes.
1. Four stroke cycle.	Discuss high points of movie.	Participate in class discussion.
a. Requires four strokes of piston (intake, compression, power and exhaust) to produce one power stroke. Two revolutions of crankshaft are necessary to complete the four stroke cycle.		
2. Two stroke cycle.		
a. Every up stroke is compression stroke.		
b. Every down stroke is power stroke.		
c. Exhaust and intake occur at bottom of power stroke and before start of compression stroke.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Fires each time piston comes to top dead center (T.D.C.).		
e. Each revolution of crankshaft produces one (1) power stroke.		
E. Engine measurements.	II.E. Have class refer to illustrations in Automotive Mechanics, 6th edition, pp. 67 - 77, and discuss engine measurements.	II.E. Open text to pages directed by instructor and follow discussion.
1. Bore and stroke.		
a. Determine piston displacement.		
(1) II R^2 x stroke x No. cylinders equals total displacement of engines.		
b. Bore - inside diameter of cylinder in inches.		
c. Stroke - the distance piston travels from bottom dead center to top dead center.		
(1) Stroke is equal to twice the length of the crankshaft throw.		
d. Bore always given first (3 3/4" x 3 7/8") or 3.750 x 3.875).		
2. Piston displacement.		
a. Cubic inches of area in the cylinder when piston is at bottom dead center.		
b. Computing of piston displacement.		

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(1) Area of piston head multiplied by the length of the stroke in inches (II R^2 x stroke x No. cylinders = total displacement of engine) or - .7854 x D^2 x stroke x No. cylinders = total displacement (D = diameter of cylinder).

3. Compression ratio.

a. Comparison of volume of cylinder when piston is at B.D.C compared to volume when piston is at T.D.C.

(1) Cylinder volume at B.D.C. ÷ volume T.D.C.

b. Compression ratio of present day gasoline engines 8 or 8 1/2 to 1.

F. Engine timing.

1. Valve timing.

a. The exact time in engine cycle when the intake and the exhaust valves open and close in relation to piston travel.

(1) Usually stated in terms of degrees of crankshaft rotation before and after T.D.C. and B.D.C.

2. Ignition timing.

a. The exact time the spark occurs in the engine cycle in relation to piston position.

II.F.1. Using training chart and chalkboard, explain valve and ignition timing diagrams. Have students refer to valve timing diagrams in Automotive Mechanics, 6th edition, pp. 135 and 136.

II.F.1. Take notes an refer to pages in text as directed.

OUTLINE OF INSTRUCTION

G. Classification of engines.

1. By cooling systems.

   a. Air cooled.

   b. Water cooled (or other liquid).

2. By cylinder arrangements.

   a. In line.

      (1) All cylinders cast in a straight line.

   b. V-type.

      (1) Two banks of cylinders mounted in a "V" shape above the crankshaft.

   c. Opposed or "flat" block.

      (1) Cylinders mounted in two side rows, each opposite a central crankshaft.

3. By valve arrangement.

   a. L-head.

      (1) Both valves in block on the same side of cylinders.

   b. I-head.

INSTRUCTOR ACTIVITY

II.G. Using cutaway engine, explain how to identify a liquid cooled, overhead valve, in-line engine.

Refer class to text Automotive Mechanics 6th edition, Ch. 5 for classification of engines.

II.G.3. Oral questions:

a. Name 3 methods of identifying engines.

b. Where are the valves located on an "I" head engine?

STUDENT ACTIVITY

Refer to text as directed for classification of engines.

OUTLINE OF INSTRUCTION

(1) Valves mounted in the head above the cylinders.

c. F-head.

(1) Intake valves located in the head, exhaust in the block.

H. Engine construction.

1. Cylinder blocks.

a. Air cooled engine.

(1) Usually employs cooling fins in place of cooling water jacket.

b. Liquid cooled engine.

(1) Must incorporate coolant passages and radiator.

2. Cylinder heads.

a. Cast iron-alloy (most frequently used).

b. Aluminum alloy (provides lighter construction, becoming more common).

INSTRUCTOR ACTIVITY

II.H. Refer class to Automotive Mechanics, 6th edition, ch. 6, for cylinder block construction, cylinder head design and crankcase components.

NOTE: Oral questions:

1. What part forms the basic framework of the engine?

2. Describe briefly the difference between a liquid cooled and air cooled cylinder block.

STUDENT ACTIVITY

II.H. Refer to text pages as directed.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Crankcase.		
a. Oil pan and lower part of cylinder block.		
b. Encloses the crankshaft.		
4. Pistons.		
a. Purpose.	II.H.4.a. Refer class to Automotive Mechanics, 6th edition, ch. 7 (engine construction).	II.H.4.a. Refer to text as directed.
(1) Receives the force of combustion and transmits this force through the connecting rod to the crankshaft.		
b. Construction.	II.H.4.b. Display actual engine pistons, rings and connecting rods and discuss purpose and construction.	II.H.4.b. Participate in class discussion while referring to text.
(1) Cast iron.		
(a) Employed in slow speed, heavy duty engines.		
(2) Aluminum alloy.		
(a) Used in high speed engines.		
(b) Also replacing cast iron pistons in many applications.		
c. Construction.	II.H.4.c. Maintain student interest by passing assorted engine parts among students during discussion.	II.H.4.c. Examine assorted engine parts for particular identifying characteristics as indicated by the instructor.
(1) Head or crown.		
(2) Boss.		
(a) Wrist pin housing.		

(3) Skirt.

(4) Ring grooves.

(5) Ring lands.

(6) Struts (for strength).

(7) Heat dam.

(a) A narrow groove above top ring.

d. Types.

(1) Camground.

(a) Slightly elliptical - as piston temperature rises, piston expands and assumes a round shape.

(2) Slotted.

(a) Horizontal slot - to control heat travel from crown to skirt.

(b) Vertical slot - to permit expansion without an increase in diameter.

5. Piston rings.

a. Purposes.

(1) To provide a good seal between piston and cylinder wall and preventing blowby.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(2) To remove excessive oil from cylinder walls preventing it from entering cylinders.

(3) Transmit heat from pistons to cylinder wall.

b. Construction.

(1) Cast iron.

(2) Steel.

(3) Surface of rings may be plated with another metal.

(a) Chrome plated to resist wear.

c. Types.

(1) Compression.

(2) Oil control.

c. Piston pins (wrist pins).

a. Purpose.

(1) Connects upper end of connecting rod to the piston.

b. Construction.

(1) Hollow steel pin, surface hardened to prevent wear.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Types. (1) Full floating pin. (a) Free to turn in both the connecting rod and the piston boss. (Retained by snap rings or plugs.) (2) Semi-floating pin. (a) Secured to the connecting rod. (3) Fixed pin (set screw). (a) Secured to the piston boss by set screws.		
	NOTE: Oral questions. 1. Name the purposes of piston rings. 2. What is the purpose of a camground piston? 3. Why are aluminum pistons used in high speed engines?	
7. Connecting rods. a. Purpose.	II.H.7. Use operational cutaway engine to demonstrate the change of reciprocating motion to rotary motion by the connecting rod.	II.H.7. View cutaway and participate in instructor directed discussion.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) To change the reciprocating of the piston to the rotary motion of the crankshaft.

(2) To transfer the force of combustion from the piston to the crankshaft.

b. Construction.

(1) Forged from steel alloy - designed to be light and strong.

c. Types.

(1) I-beam design - used on all modern high speed engines.

(a) Rifle drilled - to permit oil to pass from connecting rod journal to piston pin.

8. Connecting rod bearings.

a. Purpose.

(1) To support the enormous loads transmitted from piston.

(2) To minimize friction by retaining a sufficient lubricating film.

b. Construction.

(1) Precision insert (most common).

(a) Typical bearing construction.

1. Steel back (.125 thick).

2. Bronze inner layer (.030 thick).

3. Babbit bearing surface (.003 thick)

c. Types.

(1) Poured (integral) (made by pouring molten babbit or bearing metal into bearing seats) (requires use of shims for final fitting).

(2) Precision insert. (Made to close tolerances, must be fitted correctly.)

NOTE: Oral questions:

1. What is the purpose of a connecting rod?

2. What is the purpose of the connecting rod bearing?

3. What is the advantage of the precision type bearing over the poured type bearing?

9. Crankshaft.

OUTLINE OF INSTRUCTION

a. Purpose.

(1) To change reciprocating motion of piston to rotary motion and handles the entire power output.

(a) Often regarded as the "backbone" of the engine.

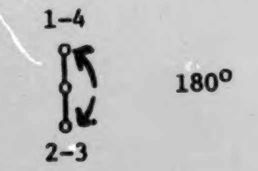
b. Construction.

(1) Cast or forged.

(a) One piece heat treated alloy steel.

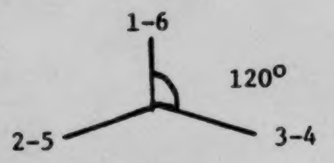
c. Crankshaft throw arrangements.

(1) Four cylinder in line.



(a) 180° between throws; 180° between power impulses.

(2) Six cylinder in line



INSTRUCTOR ACTIVITY

II.H.9.a. Display various crankshaft arrangements (4, 6 and 8 cylinder) to show and tell students throw arrangements, counter weight location and frequency of power impulses.

II.H.9.c. Using chalkboard draw diagrams showing crankshaft throw arrangements for 4, 6 and 8 cylinder four-stroke cycle engines.

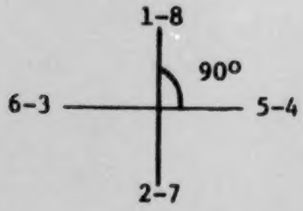
STUDENT ACTIVITY

II.H.9.a. Observe crankshaft and participate in directed discussion.

II.H.9.c. Draw similar diagrams for future study.

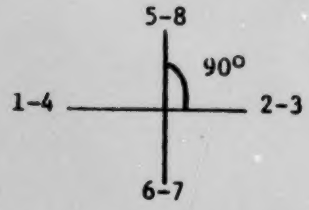
(a) 120° between throws; 120° between power impulses.

(3) Eight cylinder in line.



(a) 90° between throws; 90° between power impulses.

(4) Eight cylinder V-type.



(a) 90° between throws.

d. Counter balances or counterweights.

(1) Used to dynamically balance the crankshaft.

(2) Located opposite the crankshaft throw to counter balance the weight of the crank throw and connecting rod.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(3) Usually forged integral with the crankshaft.

e. Torsional vibrations (twisting vibrations).

II.H.9.e. Show and explain operation of vibration damper, or harmonic balance using cutaway damper unit.

(1) During each power stroke the crankshaft is subjected to a certain amount of twist from the tremendous load, at the end of the power stroke the shaft untwists. This twisting and untwisting of the crankshaft is called Torsional Vibration.

(2) To limit torsional vibrations a torsional vibration damper is used.

(a) Torsional vibration dampers (harmonic balance).

1. Usually consist of a small flexible driven flywheel mounted at the opposite end of the crankshaft from the main flywheel. The inertia of the damper flywheel will tend to keep the crankshaft rotating at constant speed and will thus oppose the vibrating force.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

10. Flywheel.

   a. Purposes.

      (1) To keep the variations in speed within desired limits at all loads.

      (2) To limit the instantaneous rise or fall in speed during sudden changes in load.

      (3) To carry the pistons over the compression pressure when running at low or idling speed.

      (4) To help bring the engine up to speed when starting.

      (5) Used as one surface for the clutch.

   b. Weight requirements.

      (1) The heavier the flywheel the smoother the idle speed.

         (a) Excessively heavy flywheel will cause the engine to accelerate and decelerate slowly because of inertia.

            1. Heavy duty or truck engines use large heavy flywheels.

II.H.10.a. Explain operation of flywheel.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Racing car or high speed engines use light flywheels.		
11. Main bearings.		
a. Purposes. (1) To support the crankshaft against the enormous loads imposed by the power impulses in the cylinder. (2) To minimize friction by retaining a sufficient lubricating film.	II.H.11.a. Explain purpose and construction of main bearings. Maintain class interest by passing out main bearing components for students to examine.	II.H.11.a. Examine main bearings as directed by instructor, discussing construction and purpose.
b. Construction. (1) Same as connecting rod bearings, but usually considerably larger in area, to provide greater load carrying capacity.		
c. Types. (1) Same material as connecting rod bearings. (2) Thrust bearings - take up end play in crankshaft.		
12. Valves and seats.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Purpose. (1) To permit air and fuel mixture to enter the cylinder and to provide an escape for exhaust gases.	II.H.12.a. Refer students to Automotive Mechanics, 6th edition, chapter 8 - Valves and Valve Trains. Point out to class valve system purposes, construction and operation.	II.H.12.a. Refer to text as directed by instructor.
b. Construction. (1) Intake valves. (a) Chromium nickel alloy. (2) Exhaust valves. (a) Silichrome alloy. 1. Sodium cooled exhaust valves have a hollow stem. Under heat sodium becomes a liquid and will transfer heat from valve head to valve stem, there the heat is transferred to the valve guides. (3) Valve face and valve seat angle usually 45° or 30°. (a) These angles reduce carbon accumulation most effectively. (4) Valve seat.		

(a) Valve seat inserts used on exhaust of most modern high output engines.

c. Types of valves.

(1) Poppet.

(a) Mushroom head.

(b) Tulip head.

13. Valve operating mechanisms.

a. For L-head engine.

(1) Camshaft.

(a) Cam lobe.

(2) Valve lifter or tappet.

(a) Valve tappet guide.

(b) Valve stem to tappet adjusting screw and locknut.

(3) Valve (intake and exhaust).

(a) Valve spring.

(b) Valve spring retainer and lock.

(c) Valve guide.

(4) Valve seat.

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OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

b. For valve in-head engine.

(1) Camshaft.

(a) Cam lobe.

(2) Valve lifter.

(3) Push rod.

(4) Rocker arm shaft.

(5) Rocker arm.

(a) Valve adjusting screw and locknut.

(6) Valve (intake and exhaust).

(a) Spring.

(b) Valve spring retainer and lock.

(7) Valve guide.

(8) Valve seat.

NOTE: Oral questions:

1. What are the buddy throws for a 6 cylinder 4 stroke cycle crankshaft?

2. What is the purpose of the crankshaft vibration damper?

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	3. What is the common name of bearings that support the crankshaft?	
	4. What is the main purpose of the flywheel?	
	5. The valve face and seat is usually ground at what angle?	
I. Gasoline engine fuel system.	II.I. Show movie, MA-8886, "Carburetor Principles of Operation" (25 min.).	II.I. View movie and take notes.
	Discuss high points of movie	Participate in directed discussion
1. Purpose of gasoline engine fuel system.	II.I.1. Refer to CM "A" IS 1.2.1.1.	II.I.1. Participate discussion, view fuel system parts as passe out by instructor.
a. Stores and delivers fuel.		
b. Varies fuel/air ratio as required.		
(1) Ideal air/fuel ratio required by engine is 15 to 1 by weight.		
(2) HIGH air to fuel ratio - lean mixture.		
(3) LOW air to fuel ratio - rich mixture.		
2. Components of gasoline engine fuel system.	II.I.2. Using training slides discuss gasoline engine fuel system; use actual fuel system parts to maintain student interest.	

OUTLINE OF INSTRUCTION

a. Fuel tank - fuel storage.

b. Fuel filters - removes solids and collects water.

c. Fuel pump - delivers fuel to carburetor.

d. Carburetor - meters, atomizes and vaporizes fuel-air mixture.

e. Intake manifold - distributes fuel/air to cylinders.

f. Fuel lines - transports fuels.

3. Characteristics of gasoline.

a. Volatility.

(1) Refers to the ease with which a liquid vaporizes.

(2) Provide good operating characteristics.

(a) Ease of starting.

(b) Freedom from vapor lock.

(c) Quick warmup.

(d) Smooth acceleration.

(e) Good economy.

(f) Freedom from crankcase dilution.

INSTRUCTOR ACTIVITY

II.I.2. Have class refer to Automotive Mechanics, 6th edition, chapters 9 and 10, to view illustrations showing fuel system parts and function.

STUDENT ACTIVITY

II.I.2. Refer to text as directed.

b. Purity.

(1) Impurities removed during refining.

c. Anti-knock quality.

(1) Smooth burning process or a fuel's ability to resist detonation.

(2) The tendency toward detonation is overcome by the addition to the fuel of such compounds as tetraethyl lead.

4. Carburetion.

a. The mixing of the gasoline fuel with air so that a combustible mixture is obtained.

b. Evaporation (vaporization).

(1) The term used to describe the action that takes place when a liquid changes to a vapor.

c. Atomization.

(1) The breaking up of the fuel into a fine spray consisting of tiny droplets of gasoline.

(a) This exposes a large surface to air for rapid vaporization.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

d. Venturi effect.

(1) Hour glass shape, creates low pressure area.

(2) Atmospheric pressure forces fuel from float bowl.

(a) Air speed increases and pressure decreases.

5. Carburetor and circuits.

II.I.5. Using training slides discuss carburetor circuits.

a. Float circuit.

(1) Controls fuel level in float bowl.

(a) High fuel level causes:

1. Rich mixture.

2. Fuel too near end of discharge nozzle.

(b) Low fuel level causes:

1. Lean mixture.

(2) Contains the following parts.

(a) Needle valve and seat.

(b) Float bowl.

(c) Float.

(d) Float bowl vent (external or internal).

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

b. Idle or low speed circuit.

(1) Delivers fuel at low engine speeds.

(a) While idling at speeds up to 20 MPH (approximately).

(2) Operation.

(a) Low pressure area created by intake stroke.

(b) Atmospheric pressure forces fuel through low speed circuit.

(c) Delivers fuel below throttle valve.

(3) Basic parts of circuit.

(a) Passage from float bowl.

(b) Low speed jet.

(c) Economizer.

(d) Idle port.

(e) Idle adjusting screw.

c. High speed, part load (circuit).

(1) Supplies fuel during change from low speed circuit to high speed circuit.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(2) During operation, the lowest pressure point changes from idle port to opening of high speed nozzle.

(3) Basic parts of circuit.

(a) Venturi.

(b) High speed nozzle.

(c) Passage from float bowl.

d. High speed full power (circuit).

(1) Supplies fuel at speeds higher than 20 MPH.

(2) During operation, lowest pressure point will be at the high speed nozzle.

(3) Basic parts of circuit.

(a) Venturi.

(b) High speed nozzle.

(c) Metering rod and jet.

(4) Types of high speed full power circuits.

(a) Mechanically operated.

(b) Vacuum operated.

(c) Combination mechanical and vacuum.

NOTE: These circuits allow additional fuel to flow at high speed.

e. Accelerator pump circuit.

(1) Supplies additional fuel during rapid acceleration.

(2) Mechanically operated pump.

(a) Linked to accelerator pedal.

1. Does not depend on atmospheric pressure.

(3) Basic parts of system.

(a) Pump.

(b) Inlet check valve.

(c) Discharge check valve.

(d) Jet.

f. Choke circuit.

(1) Provides rich mixture for starting cold engine during warm up.

(2) Reduces opening through air horn, creating a lower than atmospheric pressure at main nozzle.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Basic parts.		
(a) Choke valve.		
(b) Choke valve shaft.		
(c) Automatic or manual control.		
	NOTE: Have students trace fuel flow through carburetor circuits, explaining carburetor principles identifying circuits and major, parts.	NOTE: Trace fuel flow through carburetor while identifying circuits and major parts.
6. Fuel pump.	II.I.6. Using training slides discuss fuel pump construction and operation.	II.I.6. Follow instructor discussion and take notes.
a. Diaphragm non-positive displacement type (mechanical and electrical).		
(1) Transfers fuel from tank to carburetors.		
(2) Construction and operation.		
(a) Rocker arm.		
(b) Diaphragm.		
(c) Diaphragm spring.		
(d) Inlet valve.		
(e) Outlet valve.		
(f) Fuel passages and chamber.		
(3) Inlet stroke.		

OUTLINE OF INSTRUCTION

- (a) Inlet valve opens, discharge closes.
- (b) Creates low pressure area in pump chamber.
- (c) Atmospheric pressure forces fuel into pump.

(4) Return stroke.

- (a) Diaphragm spring tension moves diaphragm.
- (b) Forces fuel to carburetor.
- (c) Only delivers fuel when needle valve is off of seat.

(5) Fuel filter.

- (a) On pumps with fuel filter service the same as any other fuel filter.

7. Air cleaners (types, function and servicing).

a. Oil wetted type.

(1) Copper mesh screen wetted with engine oil filters incoming air to carburetor.

- (a) Clean periodically in solvent and re-oil.

(2) Oil bath type.

INSTRUCTOR ACTIVITY

II.I.7. Refer to Automotive Mechanics, 6th edition, ch. 9 and 20, for illustrations showing air cleaner types, function and servicing.

STUDENT ACTIVITY

II.I.7. Refer to text and follow discussion by instructor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Reverses incoming air flow causing heavy particles of dust and other contaminants to strike the oil bath.		
1. Wash in solvent periodically and replace oil with clean engine oil.		
(3) Paper element type.		
(a) Filters air through microscopic pores.		
1. Change as manufacturer recommends.		
(4) Polyurethane type.		
(a) Polyurethane element is supported on a wire frame and is a highly efficient filter.		
1. Remove as prescribed by manufacturer and wash in solvent then dip in oil, ring out, then re-install in filter housing.		
8. Intake manifolds, function and construction.	II.I.8. Using actual manifolds discuss function and construction in accomplishing the intake of fuel air mixture and the exhausting of burned gases.	II.I.8. Observing manifolds, participate in directed discussion.

OUTLINE OF INSTRUCTION

a. Purpose.

  (1) To direct the fuel and air mixture to the cylinders.

  (2) Construction.

    (a) Straight and smooth as possible to reduce chances of condensation and reduce friction.

    (b) Heat control valve.

      1. To help promote better vaporization of the fuel by directing exhaust gases through a passage in the intake manifold thereby heating the base of the carburetor.

9. Exhaust manifold, function and construction.

  a. Purpose.

    (1) To carry exhaust gases away from the cylinders.

  b. Construction.

    (1) Usually cast iron-free of unnecessary bends.

10. Muffler function.

  a. Function.

INSTRUCTOR ACTIVITY

II.I.9. Have class refer to Automotive Mechanics, 6th edition, pp. 107 - 108 to study illustrations of intake and exhaust systems.

STUDENT ACTIVITY

II.I.9. Refer to text illustrations as directed by instructor.

OUTLINE OF INSTRUCTION

(1) Reduces noise by cooling exhaust gases.

(2) Arrest flames and sparks.

INSTRUCTOR ACTIVITY

NOTE: Oral questions:

1. What are the two (2) main purposes of the gasoline engine fuel system?

2. What are the two (2) changes that affect air as it passes through a venturi?

3. Which circuit of the carburetor controls the flow of gasoline from the fuel pump?

4. In the fuel pump, what operates the diaphragm on the return stroke?

5. What affect would a clogged air cleaner have on engine performance?

6. Which part of the fuel system directs the fuel-air mixture to the engine cylinders?

7. Give the two (2) functions of the muffler.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
J. Engine cooling systems.	II.J. Explain that the cooling of an engine is a controlled process of getting rid of the excess heat of combustion. Explain how the temperature is regulated to provide maximum engine efficiency.	II.J. Take notes.
1. Purpose.	II.J.1. Show movie, "Cooling System", Ethyl Corp. (20 min.).	II.J.1. View movie.
a. Maintain efficient engine operating temperature at all engine speeds and all driving conditions.	Refer to CM "A" IS 1.2.1.1. Review high points of movie.	Follow instructor lecture referring to CM "A" IS 1.2.1.1.
b. Need for cooling.		
(1) Combustion temperatures as high as 4500°F.		
(a) Oil breakdown.		
(b) Damage to metal.		
2. Function and construction.	II.J.2. Have class refer to Automotive Mechanics, 6th edition, ch. 12 to view illustrations showing cooling system function and construction.	II.J.2. Refer to text as directed.
a. Types of cooling systems.		
(1) Forced circulation.		
(a) Open cooling system.		
1. Marine cooling where lake or ocean water is circulated through the engine cooling system.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(b) Closed cooling system.

1. Radiator employed on autos, buses, trucks, tractors, etc.

2. Heat exchanger - used on marine equipment - sea water is used to cool fresh water in cooling system.

b. Types of coolants.

(1) Water.

(a) Additives.

1. Rust inhibitor.

2. Anti-freeze.

(2) Permanent coolant.

(a) Factory installed.

3. Associated parts for typical automotive cooling system.

a. Radiator.

(1) Tubular type.

(a) Vertical tubes for coolant flow.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(b) Horizontal fins for heat transfer from tubes to cooling air.

(2) Honeycomb type (cellular).

(a) Narrow water passages formed by pairs of thin metal ribbons.

(b) Passages are separated by air fins also constructed of metal ribbon.

b. Pressure caps.

(1) Purpose.

(a) Permit build up of pressure in cooling system to increase boiling point of coolant.

1. Each pound built up raises boiling point about 3 1/4°F.

2. Blow off valve permits relief of excess pressure.

3. Vacuum valve admits air to enter cooling system while engine cools.

c. Fan and shroud.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(1) Fan (two to eight blades).

(a) Draws or blows air through radiator.

(2) Shroud.

(a) Assures that all air moved by the fan passes through radiator.

d. Thermostat.

(1) Temperature sensitive valve.

(a) Placed inside water outlet of cylinder block.

(b) Regulates coolant temperature.

(c) With the thermostat closed, the water circulates entirely within the engine block thus warming up more rapidly.

(d) When the water becomes warm enough to open the thermostat, the water circulates through it into the radiator and thus normal cooling action is obtained.

e. Water jackets.

(1) Construction.

(a) Usually cast into the engine block and head.

f. Temperature gauge.

(1) Purpose.

(a) Warns operator of abnormal temperature rise.

(2) Types.

(a) Electrical.

(b) Pressure (do not bend or kink pressure line).

g. Water pump.

(1) Forces coolant from radiator outlet hose through engine block.

(2) Causes cooling system fluids to circulate within the system.

(a) Usually a centrifugal non-positive displacement type pump.

4. Air cooling systems.

a. Air cooling of a reciprocating piston engine as used in an automobile requires constant circulation of large quantities of air.

(1) Fan of generous size directs air over tapered radiation fins, which are part of or attached to the cylinder head and walls.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Some small air cooled engines depend entirely upon movement for air flow.		
	NOTE: Use cutaway engine and actual cooling system components, have students trace coolant flow through system while identifying parts.	NOTE: Trace flow of coolant and identify parts.
	NOTE: Oral questions: 1. What are the two (2) types of forced circulation cooling systems? 2. What two (2) functions are accomplished by using additives in the cooling system? 3. Which device in the cooling system raises the boiling point of the coolant? 4. Which device regulates coolant temperature? 5. What type cooling system makes extensive use of cooling fins?	
K. Engine lubricating systems: 1. Purpose. a. Lubricate moving parts.	II.K.1. Using training slides and cutaway engine with assorted engine parts, discuss engine lubricating system function, construction and operation.	II.K.1. Participate in discussion and take notes.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(1) To minimize wear.

(2) To minimize power loss from friction.

(3) Prevents metal to metal contact.

b. Remove heat by acting as a coolant.

c. Absorb shock between bearings.

d. Form seal between cylinder walls and piston rings.

e. Assist in keeping engine clean.

(1) Detergent.

2. Lubricant properties.

a. Refined from crude oil.

(1) Additives.

(a) Counteract oxidation.

1. Resist metal deterioration.

(b) Cleaning of engine components.

1. Removal of carbon and varnish from engine parts.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Anti-foaming agents.		
3. Viscosity. a. Viscosity refers to the tendency of an oil to resist flowing. b. The higher the SAE number, the higher will be the viscosity of the oil. (1) SAE 40 has a higher viscosity than SAE 10.	II.K.3. Explain to class the difference between low and high viscosity oils.	
4. Lubrication system components, purpose and function. a. Oil pumps. (1) Are positive displacement. (2) Types. (a) Gear type. (b) Rotor type. (3) Principles of operation. (a) Gears or rotors revolve forcing oil into pump cavity and around gears. (b) Gear action causes pressure which forces the oil around the outside of each gear.	II.K.4. Using training slides and cutaway engine and assorted engine parts explain function and purpose of lubricating system components.	II.K.4. Follow instructor lecture and examine parts as passed out by instructor.

(4) Relief and regulating valve.

(a) Prevents excessive pressure.

(b) Pump delivers more pressure than required then valve will open allowing excessive oil to return to oil pan.

b. Oil gauges.

(1) Pressure gauge.

(a) Pressure expansion type.

1. Bourdon tube.

(b) Electric type.

1. Balancing coil.

2. Thermostatic blade.

(2) Oil gauge.

(a) Bayonet type (dipstick).

1. Indicates level of oil in reservoir; does not indicate quantity.

c. Oil strainers.

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(1) Purpose.

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(a) To remove large particles of dirt and sludge from oil before entering pump.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

d. Oil filters.

(1) Types of filters.

(a) By-pass filter.

1. Part of oil to system and part to filter.

(b) Full flow filter.

1. All oil passes through filter before entering system.

a. Employs a valve to by-pass filter if clogged.

(2) Service.

(a) Remove filter element (at specified intervals).

1. Discard if replaceable type.

(b) Clean filter housing.

(c) Install new element.

1. Use new gasket on cover (lightly oil gasket).

e. Crankcase ventilators.

(1) Breather tube method (road draft tube).

(a) Non-positive (practically obsolete).

(2) Positive method (positive crankcase ventilation).

(a) Draws engine crankcase vapors by using intake manifold vacuum.

(b) (P.C.V.) valve must be cleaned at regular intervals (flow control valve).

f. Oil cooler.

(1) Purpose.

(a) Acts to cool the oil only; seldom used on gasoline engines.

g. Types of lubricating systems.

(1) Splash.

(a) Dippers on connecting-rod bearing caps.

1. Dippers pick up oil, lubricating the connecting rod bearings and splashing oil in the form of a fine mist lubricating the following engine parts.

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a. Valve train.

b. Wrist pins.

c. Cylinder walls.

d. Piston rings.

(b) Oil pump provides oil from sump to trays.

(2) Pressure feed.

(a) Oil is forced from sump to main oil gallery; from there it lubricates the following:

1. Main bearings.

2. Connecting rod bearings.

3. Cam shaft bearings.

4. Wrist pin.

5. Valve train.

6. Cylinder walls (usually from spit holes in connecting rod).

(3) Combination splash and pressure feed.

(a) Depends on both systems to adequately lubricate engine.

OUTLINE OF INSTRUCTION

III. Application.

A. Knowledge gained by the student in this topic will be applied throughout the engine phases of the course.

IV. Summary.

A. Internal combustion engine principles.

B. Basic components and mechanical principles.

C. Engine operation.

D. Engine types.

E. Engine measurements.

F. Engine timing.

INSTRUCTOR ACTIVITY

NOTE: Oral questions:

1. Name three functions of the lubricating system.

2. What is viscosity?

3. Describe the operation of a gear type oil pump.

4. What is the function of the pressure relief valve?

5. What are the two types of oil filters?

6. What is the purpose of the P.C.V. valve?

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
G. Classification of engines.		
H. Engine construction.		
I. Gasoline engine fuel system.		
J. Engine cooling systems.		
K. Engine lubricating systems.		
V. Test:		
A. Written test.		
VI. Assignment:		
A. Read Automotive Electrical Equipment, 7th edition, McGraw Hill Book Co., chapters 1 and 2.	VI.A. Pass out Automotive Electrical Equipment, 7th edition, McGraw Hill Book Co.	VI.A. Read assignment for topic 1.2.2 as directed by instructor.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Electrical System Principles

Average Time: 18 Periods (Class), 4 Periods (Pract)

Instructional Materials:

A. Texts:

1. Automotive Electrical Equipment, 7th edition, McGraw-Hill Book Co., chapters 1 and 2.

2. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., chapters 13, 14, 15 and 16.

B. References: None.

C. Tools, Equipment and Materials:

1. Major.

   a. Ford 6 cylinder gasoline engine (12 each).

2. Materials (consumable).

   a. Batteries.

   b. Charging system components.

   c. Cranking system components.

   d. Ignition system components.

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1 Gasoline Engine Disassembly, Inspection and Assembly and CM "A" JS 1.2.6.1, Gasoline Engine Diagnosis and Adjustment. Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of 37° to 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operatin range.

Enabling Objectives: Upon completion of this topic each student will be able to identify by name the following electrical system components; the ignition system, the cranking system, the charging system, the lighting system and the accessory system and explain the operating principles of each system with 100% accuracy. Each student will be evaluated on a continuing basis throughout engine disassembly, assembly and specifically CM "A" JS 1.2.6.1, "Gasoline Engine Trouble Diagnosis and Adjustment".

Criterion Test: Identify by name all electrical system components, while explaining operating principle of the electrical systems, when called upon by the instructor during classroom participation and shop practices.

D. Training Aids and Devices:

1. Films:

   a. MN-8016-A, "Basic Electricity, The Electron Theory" (5 min.).

   b. MN-8016-B, "Basic Electricity, How Magnets Produce Electricity" (3 min.).

   c. MN-8594-A, "Direct Current Generators, Theory of Operation" (16 min.).

   d. MN-8594-B, "Direct Current Motors, Theory of Operation" (10 min.).

2. Slide Films:

   a. Delco-Remy 35mm strip films.

      (1) 9010 K - Introduction to Automotive Electrical System.

      (2) 9011 K - Delcotron Generator and the Charging Circuit.

      (3) 9020 K - 20,000 volts Under the Hood (the ignition circuit).

      (4) 9025 K - The Cranking Circuit.

3. Devices:

   a. NP-17008, Device 6AZ Engine Internal Combustion, Electrically Operated.

4. Charts:

   a. Delco-Remy Training Charts.

Homework: Read Automotive Electrical Equipment, 7th edition, McGraw-Hill Book Co., chapters 1 and 2.

(1) Section "A" - Fundamentals of Electricity and Magnetism.

(2) Section "B" - Energizers and Batteries.

(3) Section "C" - Cranking Motors.

(4) Section "D" - Ignition System.

(5) Section "E" - Generators - DC Type.

(6) Section "K" - Fundamentals of Delcotron Generators - AC Type.

5. Locally Prepared Materials:

a. Information sheets.

(1) CM "A" IS 1.2.2.1, "Maintenance of Lead-Acid Storage Batteries".

(2) CM "A" IS 1.2.2.2, "Principles of Electricity".

(3) CM "A" IS 1.2.2.3, "Electrical Circuits".

E. Training Aids Equipment:

1. 16mm movie projector.

2. 35mm slide projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Electrical System Principles.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives. 1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.	II. Pass out information sheet CM "A" IS 1.2.2.2, Principles of Electricity.	II. Follow instructor lecture taking notes and referring to information sheet.
A. Operating principles of electrical components.		
1. Composition of matter and electricity.	II.A.1. Teach each principle for a purpose, then apply the principles to the electrical system and related components using charts and chalkboard.	
a. Composition of matter.		
(1) Molecule.		
(a) The combination of two or more atoms.		
(2) Atom.		
(a) The smallest physical particle into which an element can be divided.		
(3) Electron.		
(a) The small negatively charged particle which is practically weightless.		
(4) Free electrons.		
(a) Electrons in the outer orbits of an atom which can easily be forced out of their orbits.		
(5) Electron Theory.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Flow is from negative to positive.		
b. Electricity. (1) The effect of electrons in moving from point to point. (2) Gathering of electrons is called a charge of electricity. (3) Definition of circuits. (a) Complete or closed. (b) Open. (c) Short. (d) Grounded.	II.A.1.b. Instructor demonstrate and explain closed, open, short and grounded circuits using chalkboard and charts.	II.A.1.b. Follow instructor lecture taking notes and referring to informatic sheet.
c. Three types of circuits. (1) Series - one path for current to flow. (2) Parallel - two or more paths for current to flow. (3) Series - parallel - combination of the two.	II.A.1.c. Using chart and chalkboard, explain and demonstrate the three (3) types of circuits.	II.A.1.c. Draw diagrams of three (3) types of circuits.
2. Amperage and voltage. a. Amperage.	II.A.2. Using chart and chalkboard, explain amperage, voltage resistance and magnetism.	II.A.2. Participate in instruction and take notes.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(I) Measure of current (electron) flow.		
b. Voltage.		
(1) Measure of pressure used to move electrons.		
3. Resistance.		
a. Measure of opposition to flow of (electrons) current.		
b. Conductors and insulators.		
(1) Conductors.		
(a) Path for flow of (electrons) current.		
(2) Insulators.		
(a) Prevents flow of (electrons) current.		
c. Effected by.		
(1) Length of conductor.		
(2) Size of conductor.		
(3) Temperature.		
(4) Material of conductor.		
4. Magnetism.	II.A.4. Using battery, coil of wire, iron core and iron filings, demonstrate electromagnetic principles.	II.A.4. Participate in demonstration and take notes.

a. Magnetic field.

  (1) Magnetic lines of force surround magnet.

    (a) Pass from north pole to south pole.

    (b) Never cross.

    (c) Cannot be insulated.

b. Effect between magnetic poles (laws).

  (1) Unlike attract.

  (2) Like repel.

c. Electromagnetism.

  (1) Flow of current produces magnetic field.

  (2) Coil of wire forms electromagnet.

  (3) North pole determined by left hand rule.

    (a) Left hand held around coil, fingers pointing in direction of current flow, thumb points to north pole.

  (4) Strength of electromagnet.

    (a) Increased by wrapping coil around iron core.

      1. Core passes lines of force better than air.

OUTLINE OF INSTRUCTION

d. Electromagnetic induction.

   (1) Current will be induced to flow in conductor passed through a magnetic field.

      (a) Same effect if magnetic field is moved.

         1. Relative motion.

            a. Conductor moves, magnetic field stationary.

            b. Magnetic field moves conductor remains stationary.

            c. Current flow turned on and off causing magnetic field to build up and collapse.

INSTRUCTOR ACTIVITY

II.A.4.d. Using a galvanometer, a permanent magnet, and coil of wire, demonstrate induction of current.

NOTE: Oral questions:

1. What is electricity?

2. What is an open circuit?

3. Name the three (3) types of circuits.

4. Describe amperage.

5. What is voltage?

STUDENT ACTIVITY

II.A.4.d. Participate in demonstration and take notes.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	6. What is the difference between a conductor and an insulator?	
	7. Describe a magnetic field.	
	8. What are the two (2) laws that govern magnetic poles?	
	9. How would you increase the strength of an electromagnet?	
	10. What is the result when a magnetic field is passed through a conductor?	
	NOTE: Show movies:	
	1. MN-8016-A, "Basic Electricity, The Electron Theory" (5 min.).	1. Observe movies and take notes.
	2. MN-8016-B, "Basic Electricity, How Magnets Produce Electricity" (3 min.).	
	NOTE: Review and discuss high points of movie.	Participate in discussion.
5. Storage battery. a. Construction.	II.A.5. Use Delco-Remy chart Section "B" - Energizers and Batterics to show battery construction and explain function.	

OUTLINE OF INSTRUCTION

(1) Three or more cells connected in series.

  (a) Three cells = 6 volts.

  (b) Six cell = 12 volts.

(2) Plates.

  (a) Cell consists of:

    1. Positive plates (brown lead peroxide).

    2. Negative plates (gray spongy lead).

    3. Assembly of positive and negative groups with the separators are called an element.

(3) Separators.

  (a) Prevents short circuits between plates.

  (b) Made of wood, porous rubber or spun glass.

  (c) Inserted between plates.

    1. Wood separators are not used in dry charged batteries.

INSTRUCTOR ACTIVITY

II.A.5.a.(3) Pass out components of cutaway battery to show battery construction.

STUDENT ACTIVITY

II.A.5.a.(3) Participa in class discussion of battery construction and function while observing details on charts and viewing actual battery components.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(4) Cell connectors.		
(a) Connects cells of battery together in series.		
(b) Must be heavy to carry high current required during starting.		
(5) Terminal posts.		
(a) Special design - tapered to specified dimensions (on most batteries).		
1. Positive terminal.		
a. Largest post.		
2. Negative terminal.		
a. Smallest post.		
(6) Cell cover.		
(a) Prevents dirt and other foreign material from entering cell.		
(b) Vent plugs.	II.A.5.a.(6) Pass out CM "A" IS 1.2.2.1, "Maintenance of Lead-Acid Storage Batteries".	II.A.5.a.(6) Scan Information Sheet and retain for use later in course.
1. To allow gases formed in battery to escape.		

(7) Case (container).

(a) Usually one piece molded type.

(8) Electrolyte.

(a) Sulfuric acid and distilled water.

(b) Specific gravity readings.

1. 1.260 - 1.290 fully charged battery.

2. 1.230 - 1.260 about three fourths charged.

3. 1.200 - 1.230 about half charged.

4. 1.170 - 1.140 discharged.

(9) Principles of operation.

(a) Discharge of battery.

1. Current flow from battery causes sulfuric acid to pass from the electrolyte to the plates.

(b) Charge of battery.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
1. Direct current source connected to battery terminals.		
a. Current flow causes sulfuric acid to move from plates into the electrolyte.		
(c) Charging battery.		
1. Constant-current method.		
a. Steady flow of current (amperage). Usual rate one ampere per positive plate of the smallest cell.		
	NOTE: Oral questions:	
	1. Each cell of a battery is capable of producing how many volts?	1. Two.
	2. Of the two terminal posts on a storage battery, which one is the largest?	2. Positive.
	3. A fully charged battery would have a specific gravity reading of approximately -	3. 1.260 - 1.290.
6. Cranking system.	II.A.6. Show movie MN-8594-B, "Direct Current Motors, Theory of Operation". (10 min.).	II.A.6. View film.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	II.A.6. Review film and discuss high points.	II.A.6. Participate in class discussion of film.
a. Cranking motor. (1) Purpose. (a) Changes electrical energy to mechanical motion.		
(2) Principle of operation. (a) Rotation due to repulsion between field magnetism and magnetic field set up around armature windings. 1. Fields of like polarity.	II.A.6.a.(2) Explain construction and operation of cranking system while using Delco-Remy chart, section "C" Cranking Motors and slides 9025K to show details.	II.A.6.a.(2) View chart and follow instructor lecture covering cranking system construction and operation.
(3) Construction. (a) Same generally as a generator. (b) Brushes are copper alloy instead of carbon.		
b. Cranking motor drives. (1) Bendix inertia. (a) Utilizes twisting motion of cranking motor for engagement with flywheel.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Overrunning clutch. (a) Method of engagement. 1. Manually - by employing pedal shift. 2. Electrically - by employing a solenoid shift. c. Cranking motor switches and solenoids. (1) Types and purpose. (a) Solenoid. 1. Produces mechanical movement and completes a circuit. (b) Magnetic. 1. Completes a circuit (no mechanical movement transmitted). (2) Principle of operation. (a) Electromagnetism. NOTE: Cranking motor does not start engine; it merely cranks the engine.		
3. D.C. Charging system. a. Generator. (1) Converts mechanical energy to electrical energy.	II.A.7 Using Delco-Remy training charts and assorted charging system parts, discuss construction and basic operation of D.C. charging system.	II.A.7. Participate in discussion and examine charging system parts.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Components.		
(a) Armature.		
(b) Field Frame.		
(c) Field coils and pole shoes.		
(d) Commutator.		
(e) Brushes.		
(3) Operating principles.	II.A.7.a.(3) Show movie MN-8594-A, "Direct Current Generator, Theory of Operation", (16 min.).	II.A.7.a.(3) View movie
(a) Induced current.		
1. Loop revolved in magnetic field.	Review and discuss high points of movie.	Participate in instructor discussion covering movie.
(b) Commutation.		
1. Means of changing alternating current to direct current.		
(c) Amount of current induced.		
1. Increased by.		
a. Additional loops.		
b. Loops wound on iron core.		
(d) Field windings.		

1. Increases strength of magnetic field.

(4) Shunt-wound generator.

(a) 8 to 12 percent of generated current is shunted through field coils.

(b) Residual magnetism.

1. Magnetism retained by pole pieces when generator is not operating.

2. Permits build-up until current flows in field coils.

b. Generator regulator. (Extreme variation of speeds of generator makes regulation necessary.)

(1) Reverse current or circuit breaker.

(a) Electromagnetic switch in battery charging circuit that opens and closes the circuit between generator and battery.

(b) When voltage of generator exceeds battery voltage, points close.

(c) When battery voltage exceeds generator voltage, points open.

(2) Current regulator.

(a) Regulates amount of amperage flowing in generating system.

(b) Amperage low, points held closed by spring tension.

(c) Amperage high, points open.

(d) When points are open, field current forced to flow through resistors, decreasing field magnetism and thus decreasing generator output.

(e) Voltage and current regulators do not function at the same time except during build-up when points of both are closed.

(4) Voltage regulator.

(a) Safety device, as it automatically controls output of generator.

(b) Points are closed when unit is not operating.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Points open and close rapidly (vibrate) when voltage output of generator exceeds set rate.		
	NOTE: Have students identify charging system components on training chart and explain their function.	Identify charging system components and explain function.
	NOTE: Oral questions. 1. What is the purpose of a generator? 2. What is the purpose of a commutator? 3. What device prevents the battery from discharging through the generator? 4. What is the purpose of residual magnetism in the generator pole pieces?	Answer questions as called on by instructo
8. A.C. charging system.		
a. A.C. generator.		
(1) Converts mechanical energy to electrical energy.	II.A.8.a.(1) Using Delco-Remy training charts, show and explain A.C. charging system parts and function.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	II.A.8.a.(1) (cont'd) Show Delco-Remy strip film 9011K, "Delcotron Generator and the Charging System.	
(2) Components. (a) Rotor assembly. (b) Stator assembly. (c) Brush assembly. (d) Slip rings. (e) Positive heat sink. (f) Diode end frame. (g) Drive end frame. (h) Ball bearing (front). (i) Needle bearing (rear). (j) Cooling pan. (k) Drive pulley.	II.A.8.a.(2) Pass out actual charging system components for students to identify during lecture.	II.A.8.a.(2) Participate in instructor directed discussion; identify charging system components passed out by instruct
(3) Operating principles. (a) Induced current. 1. Magnetic field revolved in stationary loop. (b) Rectification.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

1. Achieved by the use of positive and negative diodes.

(c) Regulation.

1. Single unit regulator.

2. Double unit regulator.

3. Transistorized regulator.

(4) Maintenance.

(a) NEVER polarize.

(b) Never short circuit for any test.

(c) Never run an open circuit.

(d) When jump starting vehicle with booster battery go from POSITIVE to POSITIVE, NEGATIVE to NEGATIVE.

(e) To quick charge battery, isolate from charging circuit.

(f) Keep oil and grease off of housing.

(g) If water soaked, allow to dry before using.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	NOTE: Oral questions: 1. By what means is rectification accomplished in the A.C. charging system? 2. Why does the A.C. generator require diodes? 3. What do diodes do?	
9. Ignition system.	II.A.9. Using Delco-Remy chart section "D", Ignition System and Strip Film 9020K, "20,000 Volts Under the Hood (The Ignition Circuit)", show and explain construction and operation of the ignition system.	II.A.9. Participate in instructor directed discussion while viewing charts and film.
a. Parts and function. (1) Battery and generator. (a) Source of electricity for ignition system. (2) Ignition switch. (a) Closes circuit between electrical supply and ignition system. (3) Ignition coil.	II.A.9.a. Pass out ignition system parts for students to identify during lesson.	II.A.9.a. Identify ignition system parts as passed out by the instructor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(a) Transforms low battery voltage to high voltage (as much as 20,000 volts).

(b) Operation.

1. Battery current flows through primary winding when ignition switch is closed and the breaker points are closed.

(c) When breaker points open, the magnetic field collapses inducing voltage into the secondary windings.

(4) Ignition distributor assembly.

(a) Functions.

1. Opens and closes primary circuit via the breaker points.

2. Times this by means of breaker cam.

3. Directs high voltage to proper spark plug.

(b) Distributor cam.

1. Causes breaker points to open.

(c) Breaker points.

1. Opens and closes primary circuit.

    a. Opened by the distributor cam.

    b. Closed by spring tension.

(d) Condenser (capacitor).

1. Stores voltage briefly during collapse of magnetic field.

    a. Helps prevent arcing at breaking points.

(e) Rotor.

1. Mounted on top of distributor shaft.

2. Directs high voltage to proper spark plug.

(f) Distributor cap.

1. Acts as a cover for the distributor.

2. Contains high tension terminals.

OUTLINE OF INSTRUCTION

(g) Centrifugal spark advance.

1. Advances spark.
2. Retards spark.
3. Reacts to engine speed only.

(h) Vacuum spark advance.

1. Advances spark at part throttle.
2. Reacts to engine load.

(i) Spark plugs.

1. Supplies fixed gap across which high voltage surges must jump.
2. Heat range.
    - a. Hot plugs - low speed, stop and go city driving.
    - b. Cold plugs - high speed, freeway, interstate.

INSTRUCTOR ACTIVITY

NOTE: Direct students in tracing current flow through ignition system as depicted on training chart.

STUDENT ACTIVITY

NOTE: Trace current flow through system as depicted on training chart.

NOTE: Spark plugs are available in a heat range between hot and cold for use by the average vehicle - a combination of freeway and city driving.

OUTLINE OF INSTRUCTION

10. Lighting system

  a. Parts and functions.

    (1) Lamps.

      (a) Construction.

        1. Single or double contact.

        2. Single or double filament.

    (2) Sealed beam lamps.

      (a) Headlights.

        1. Usually sealed beam type.

      (b) Adjusting headlights (general).

        1. Modern type headlights are fixed focus.

        2. Only aiming need be adjusted.

        3. Aiming must meet legal requirements.

    (3) Lamp sockets.

      (a) May be of the twist or straight plug/spade type.

INSTRUCTOR ACTIVITY

II.A.10. Refer students to Automotive Mechanics, 6th edition, chapter 16 to view schematics covering electrical devices.

Pass out actual components such as lamps, fuses, circuit breakers, oil pressure gauges, ammeters, fuel gauges, temperature gauges, speedometer/odometer, tachometer, horns and windshield wipers.

STUDENT ACTIVITY

II.A.10.

Examine and identify accessories and electrical devices as passed out by instructor.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(4) Switches, fuses and circuit breakers.

(a) Switches.

1. Headlight.

2. Ignition.

3. Dimmer.

4. Heater/wipers.

(b) Fuses and overload breakers.

1. Fuses are protection against overloading circuits.

a. Must be replaced when burned out.

b. Correct the cause of fuse burning out.

2. Overload breakers offer same protection as fuses.

a. Automatically open circuit when it becomes overloaded.

b. Manually or automatically reset after cause is eliminated.

11. Accessories.

 a. Gauges.

  (1) Ammeter.

   (a) Indicates amount of current flowing to and from the battery.

    1. Cranking motor current does not go through ammeter.

   (b) Battery generator indicator/indicating light may be substituted for ammeter.

  (2) Fuel level gauge.

   (a) Indicates the amount of fuel in the tank.

  (3) Oil pressure gauge.

   (a) Indicates engine oil pressure.

  (4) Temperature gauge.

   (a) Indicates temperature of engine coolant.

  (5) Speedometer, tachometer, odometer and hourmeter.

   (a) Speedometer.

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- 1. Indicates miles/kilometers per hour.

(b) Tachometer.

- 1. Indicates revolutions per minute of engine's crankshaft.

(c) Odometer.

- 1. Records distance travelled in miles/kilometers

(d) Hour meter.

- 1. Records engine operating hours.

b. Horn.

(1) Vibrator type.

(a) Operates on principle of vibrating coil.

(b) Tone and volume may be adjusted.

(c) May be dual installation.

c. Windshield wiper.

(1) May be either electrically, vacuum or air operated.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Student practice.	III.A. Direct student activity in tracing circuitry and identifying components of cranking, charging and ignition systems as found in training aid Ford 6 cylinder gasoline engines.	III.A. Trace circuitr and identify component of cranking, charging and ignition systems on Ford 6 cylinder gasoline engines.
IV. Summary.		
A. Composition of matter and electricity.		
B. Storage battery.		
C. Cranking system.		
D. D.C. charging system.		
E. A.C. charging system.		
F. Ignition system.		
G. Lighting system.		
H. Accessories.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Gasoline Engine Disassembly

Average Time: 4 Periods (Class), 7 Periods (Pract)

Instructional Materials:

A. Texts:

1. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., Chapter 2.

2. 1969 Ford Truck Shop Manual, Vol. 2, Ford Service Publication, Ford Motor Co., Dearborn, Michigan 48207, pp. 8-04-01 - 8-04-07.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

   a. Shop tools.

   b. Automotive handtools.

2. Equipment.

   a. Major.

      (1) Ford, model 240 C.I., 6 cylinder gasoline engine (12 each).

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly" and CM "A" JS 1.2.6.1, "Gasolin Engine Diagnosis and Adjustment". Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C.. dwell of 37° - 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Enabling Objectives: Upon completion of this topic each student will be able to disassemble a six cylinder gasoline engine while working as a member of a two (2) man team, using a Ford, 240 cubic inch engine. He will use all appropriate handtools, special tools, and shop equipment. The task will be accomplished while adhering to manufacturer's specifications and recommendations without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".

Criterion Test: Disassemble a 6 cylinder gasoline engine while working as a member of a two student team using appropriate handtools, special tools and shop equipment while adhering to manufacturer's specifications and recommendations without deviation as specified in the Job Sheet.

3. Materials (consumable).
    a. Cleaning solvent.
    b. Gasoline.
    c. Wiping rags.
    d. Sweeping compound.

D. Training Aids and Devices:

1. Films.
    a. ABC-001, "ABC of Handtools", GM Corp. (18 min.).
    b. ABC-002, "ABC of Handtools", GM Corp. (15 min.).
    c. CAS-001, "The Case of the Slippery Oil", Dana Corp. (40 min.).

2. Locally Prepared Material:
    a. Information sheets.
        (1) CM "A" IS 1.2.3.1, "General Housekeeping".
    b. Job sheets.
        (1) CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".
    c. Work Sheets.
        (1) CM "A" WS 1.2.4.1, "Mathematics Work Sheet".

E. Training Aids Equipment:

1. 16mm Movie projector.

Homework: Study Automotive Mechanics, 6th edition, pp. 22 - 50.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Gasoline Engine Disassembly.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview.	I.D. State learning objectives.	
	1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Nomenclature, selection and safe use of shop tools.	II.A. Show movies: ABC-001 and ABC-002, "ABC of Handtools", GM Corp.	II.A. View movie and take notes.
1. Hammers.	Review high points of films.	Participate in review of films.
a. Types.		
(1) Ball Peen.		
(a) Size determined by weight of head.		
(2) Soft faced.		
(a) Plastic.		
(b) Nylon.		
(c) Rubber.		
(d) Rawhide.		
(e) Soft metal - (Brass, lead, copper).		
	NOTE: Pass out tools for student examination while discussing tool nomenclature, use and care.	NOTE: Examine tools and participate in discussion.
(3) Sledge.		
(a) Size and use determined by weight of head.		
b. Safe use.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Head must be securely attached to handle.		
(2) Handle free of cracks and splinters.		
(3) Never use handle for pry bar or wooden drift.		
(4) Hammer face must strike surface squarely.		
2. Screwdrivers.	II.A.2. Have class refer to Automotive Mechanics, 6th edition, chapter 2, to view tool illustrations while directing class discussion	II.A.2. Refer to pages of text as directed by instructor and participate in discussion.
a. Types.		
(1) Common (general purpose).		
(a) Size determined by length of shank.		
(b) Square shank (heavy duty) permits application of wrench to increase torque.		
(2) Phillips.		
(a) Designed to prevent damage to finished surface due to screw driver slipping from screwhead slot.		
(3) Offset (angle).		
(a) For work in limited space.		
(4) Clutch.		

(a) Same basic use as Phillips but provides more contact and requires less downward pressure.

b. Safe use.

(1) Never use as pry bar or chisel.

(2) Keep screwdriver blade vertical with screw head.

(3) Never hammer on end of screwdriver.

(4) Select proper size for job.

(5) Never use pliers on screwdriver.

(6) Never use screwdriver to check high electrical amperage.

(7) Guard against carrying in pockets.

3. Pliers.

a. Types.

(1) Combination (slip joint) pliers.

(a) Size determined by overall length.

(2) Diagonals.

(a) Pulling cotter pins.

(b) Cutting wire.

(3) Long nose (needle nose).

(a) Many special applications (mostly for handling small objects).

(4) Self locking (vice grip).

(a) Used where combination pliers will not grip sufficiently.

b. Safe use.

(1) Do not use pliers on nuts.

(2) Keep clean.

(3) Do not force beyond their capacity.

4. Wrenches.

a. Types.

(1) Adjustable.

(a) Open end: (TRADE NAME CRESCENT).

1. Convenient - but should not take place of standard wrenches.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

2. Always keep tight and apply pressure to stationary jaw.

(b) Pipe wrench.

1. Use on round objects only.

2. Jaws will leave marks on work.

(2) Open end.

(a) Jaws usually set at angle to facilitate use in close quarters.

(b) Used for general purpose nut or bolt removing.

(3) Box end.

(a) Used to break loose tight nuts or bolts.

(b) Can be used to loosen nuts or bolts in very tight places (15° swing).

(4) Combination.

(a) Has both open end and box end.

(b) Makes bolt or nut removal or installing easier.

(5) Socket wrenches.

(a) Regular (6 or 12 point).

(b) Deep.

1. Spark plug.

(c) Universal joint or socket.

1. Allows wrench handle to be at angle to socket.

(6) Handles.

(a) Flex (breaking BAR).

1. Great leverage for breaking loose tight nuts.

(b) Speed handle.

1. Speedy removal of nuts or bolts.

(c) Sliding offset..

1. With extension can make "T" handle.

(d) Ratchet.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

1. Allows bolts or nuts to be removed rapidly as the dog ratchets over teeth permitting handle to be backed up without removing socket from nut or bolt.

(e) Extensions:

1. Come in various lengths (2", 4", 6", etc.) to increase reach and depth.

(f) Torque wrench.

1. To tighten bolts or nuts evenly.

   a. Calibrated in foot - pounds or inch - pounds for light, delicate work.

b. Safe use.

(1) Select proper size and type.

(2) Don't push on wrench (pull).

(3) Apply pressure to fixed jaw of adjustable wrenches.

(4) Don't use hammer on wrench to break loose tight nuts or bolts (use striking wrench).

(5) Don't use pipe wrench on finished surfaces.

(6) Never use pipe or wrench handle to increase leverage.

5. Punches.

a. Types.

(1) Center.

(a) To mark location of a hole to be drilled.

(b) To mark location of parts before disassembly.

(2) Starting (drifts).

(a) Strong, can withstand heavy hammer blows.

(b) For starting the removal of pins and shafts.

(3) Pin.

(a) For removing straight or tapered pins and shafts after they have been broken loose with starting punch.

(4) Aligning.

(a) Long taper to align parts (fender holes) etc.

b. Safe use.

   (1) Never allow head of punch to become mushroomed.

   (2) Use proper punch for the job.

6. Chisels.

   a. Types.

      (1) Cold (flat).

         (a) Cut rivets.

         (b) Split nuts for removal.

      (2) Cape.

         (a) Chiseling small areas of metal.

      (3) Diamond point.

         (a) Chiseling small areas in close quarters.

      (4) Round nose chisel.

         (a) Chiseling inside radii.

   b. Safe use of chisels.

      (1) Keep cutting edge sharp.

      (2) Keep head of chisel beveled to prevent mushrooming.

(3) When chiseling, wear eye protection.

(4) Make sure work being chiseled is held securely.

7. Hacksaws.

a. Types.

(1) Adjustable frame.

(2) Fixed frame.

b. Blades.

(1) Length is the distance between centers of end holes (10" and 12").

(2) Teeth per inch and use.

(a) 14 - for cutting large section of mild material.

(b) 18 - for all around work (cast iron, tool steel, etc.).

(c) 24 - thin material (angle iron, pipe, etc.).

(d) 32 - thin material (conduit, tubing, sheet metal).

c. Safe use.

(1) Keep teeth pointed away from handle.

(2) Keep blade from jamming.

(3) Relieve pressure on return stroke.

(4) Work at a rate of about 40 to 50 strokes per minute.

(5) Select the blade with the correct number of teeth per inch for the material to be cut.

8. Files.

a. Types.

(1) Flat.

(2) Round.

(3) Square.

(4) Triangular.

(5) Half round.

b. Safe use.

(1) Always install handle on file tang before using.

(2) Never attempt to use as a pry bar.

(3) Never hammer on a file.

OUTLINE OF INSTRUCTION

9. Taps.

   a. Types of taps.

      (1) Taper tap.

         (a) A starting tap for threading inside drilled holes.

      (2) Plug tap.

         (a) To be used after the taper tap to complete thread, through entire hole.

      (3) Bottoming tap.

         (a) To be used in threading a blind hole, after starting tap has been used.

   b. Safe and correct use of taps.

      (1) Always use a tap wrench.

      (2) Best results are obtained tapping a blind hole by using all three types of taps, begin with taper tap, then plug tap and finish with bottoming tap.

      (3) Exert downward pressure until first two or three threads have been cut.

INSTRUCTOR ACTIVITY

II.A.9. Have class refer to Automotive Mechanics, 6th edition, page 40 to view illustrations showing taps and dies.

STUDENT ACTIVITY

II.A.9. Refer to pages of the text as directed by instructor and participate in guided discussion on use and care of taps and dies.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(4) Turn tap forward two complete turns, back it up one quarter turn to break the chips, then forward again to take up the slack - continue this sequence until threads are cut.

(5) When tapping blind hole, completely remove tap frequently to remove chips from bottom.

(6) Refer to a chart to determine size of tap and drill for particular taps and threads.

10. Dies.

a. To cut threads on a piece of round stock.

(1) End to be threaded should have a slight chamfer.

(2) Dies are adjustable to obtain a loose or tight fit.

(a) Several trial threadings may be necessary to obtain proper die adjustment.

(3) Die must be mounted properly in die stock.

(4) Apply even downward pressure to die stock until first two or three threads are cut.

(5) When die has started to cut, rotate die stock two quarter turns, back it off one quarter turn to break the chips and repeat the operation until sufficient threads are cut.

   (a) Use sufficient lubricant.

b. Safe and correct use.

   (1) Use correct size die for size stock being threaded.

   (2) Adjust to obtain good threaded fit.

   (3) Frequent removal of chips.

   (4) Never use dies without special die stock to hold and support the die.

11. Chain hoist.

   a. Used for most of the lifting operation in shop.

   b. Do not exceed capacity.

      (1) Usually rated in tons (1/2 ton, 1 ton, etc.).

II.A.11. When possible, take class to shop to view shop equipment.

12. Slings.

   a. Used to connect object being lifted to hoist.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

b. Don't exceed rated capacity.

13. Jacks.

    a. Types.

        (1) Hydraulic.

            (a) Check for leaks (keep full of oil and packing glands tight).

        (2) Screw (scissors).

        (3) Ratchet (bumper).

    b. Safe use.

        (1) Never use only a jack to support a vehicle when working underneath.

14. Jack stands.

    a. Types.

        (1) Adjustable.

        (2) Non-adjustable.

    b. Safe use.

        (1) Always use jack stands when working under a raised vehicle.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

15. Bench grinder.

    a. Abrasive wheels.

        (1) Coarse and fine grits.

    b. Safe use.

        (1) Tool rest should never be more than 1/8" from wheel.

        (2) Grinding should be done on face of wheel.

        (3) Always wear goggles or face shield.

        (4) Wheel must be turning at full R.P.M.

16. Electric drills.

    a. Capacity.

        (1) Largest drill chuck will hold.

    b. Safe use.

        (1) Keep work secured properly.

        (2) On break through, ease up on pressure.

        (3) Keep grounded.

            (a) A third wire must be connected to the drill and to ground (use a three wire conductor).

OUTLINE OF INSTRUCTION

17. Valve reconditioning machine.
    a. Types.
        (1) Valve refacer.
            (a) For grinding faces of valves.
        (2) Valve reseater.
            (a) For grinding valve seats in head or block.
    b. Safe use.
        (1) Follow student handout or use Manufacturer's Operation manual.

18. Pneumatic tools and compressors.
    a. Maintenance.
        (1) Bleeding to remove moisture.
        (2) Lubrication - according to Manufacturer's specifications.
        (3) Check hose and connections before use.
    b. Safe use.
        (1) Never point high pressure air hose at anyone!!!!

INSTRUCTOR ACTIVITY

II.A.17. Demonstrate use of valve refacing and reseating machines.

STUDENT ACTIVITY

II.A.17. Observe demonstration and participate in discussion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	NOTE: Oral questions. 1. What determines the size of a standard screwdriver? 2. Name two uses for diagonal pliers? 3. Describe use of a combination wrench. 4. When installing a hacksaw blade, how should the teeth point in regard to the handle?	NOTE: Answer questions as called on by instructor.
19. Lubrication equipment. a. Types. (1) Hand. (2) Pressure. b. Safe use. (1) Covered in future topics.		
B. Proper procedure for engine disassembly.	II.B. Show movie: CAS-001, "The Case of the Slippery Oil" Review and discuss high points of movie.	II.B. View movie and take notes. Participate in guided discussion.

OUTLINE OF INSTRUCTION

1. Preparation of bench areas.
   a. Make sure benches are clean and dry.
   b. Know portions of benches you are to use.
2. Arranging of engine parts.
   a. Parts are to be stowed on or under bench according to pictures on bulkheads or instructor's directions.
3. Protection of precision parts and surfaces.
   a. All machined surfaces should be placed on rags and well oiled to protect them from scratches and rust.
4. Clean and orderly working area.
   a. Benches.
      (1) Kept clean and neat at all times.
      (2) All engine parts will be arranged exactly the same way at each station.
   b. Decks.
      (1) Any oil, grease, or water spilled shall be cleaned up immediately.

INSTRUCTOR ACTIVITY

II.B. (Cont'd).
Pass out information sheet CM "A" IS 1.2.3.1, "General Housekeeping" and job sheet CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".

STUDENT ACTIVITY

II.B. (Cont'd).
Use Information sheet 1.2.3.1 as a guide to good shop practices. Use Job sheet 1.2.3.1 as a continuous guide to proper engine disassembly, inspection and assembly.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) All parts stowed on deck will be neat and in accordance with chart or instruction.		
c. Engines.	II.B.4.c. Take class to shop.	
(1) Keep painted surfaces of engines clean and dry of oil.	Assign students to engines, two-man team per engine.	
(2) Keep all machined surfaces oiled and covered with rags when not actually working on engine (noon and at night).		
d. Stands and drip pans.		
(1) Keep clean and dry at all times.		
(2) Any oil or water spilled in drip pans shall be wiped dry immediately.		
e. Oil and water cans.		
(1) Shall be wiped dry immediately after use and before being put away under bench provided for this purpose.		
	NOTE: Have students conduct inventory of tool cabinets.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Use of handtools will continue throughout the course.		
B. Disassemble a 6 cylinder gasoline engine while working as a member of a two man team using appropriate handtools, special tools and shop equipment while adhering to manufacturer's specifications and recommendations without deviation as specified in job sheet.	III.B. Direct, supervise and evaluate student performance during disassembly of 6 cylinder gasoline engine.	III.B. Disassemble a 6 cylinder gasoline engine while working as a member of a two man team using appropriate handtools, special tools and shop equipment while adhering to manufacturer's specifications and recommendations without deviation as specified in job sheet.
IV. Summary.		
A. Nomenclature, selection and safe use of shop tools.		
B. Proper procedure for engine disassembly.		
V. Test: None.		
VI. Assignment:		
A. Automotive Mechanics, 6th edition, McGraw - Hill Book Co., scan chapters 17, 18 and 19.		
B. Solve mathematics problems appearing on Work Sheet CM "A" WS 1.2.4.1.	VI.B. Hand out worksheet CM "A" WS 1.2.4.1, Mathematics "Decimals".	VI.B. Do homework assignment for topic 1.2.4 as required by CM "A" WS 1.2.4.1 and bring to class.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Inspection and Measuring of Engine Parts

Average Time: 5 Periods (Class), 10 Periods (Pract)

Instructional Material:

A. Texts:

1. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., chapters 17, 18 and 19.
2. 1969 Ford Truck Shop Manual, Vol. 2, pp. 08-01-10 thru 08-01-24.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.
    a. Automotive Shop tools.
    b. Automotive handtools.
    c. Measuring instruments.
2. Equipment.
    a. Major.
        (1) Ford, 6 cylinder gasoline engines (12 each).

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly" and CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment". Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of 37° to 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Enabling Objectives: Upon completion of this topic each student will be able to clean, inspect and measure engine parts of a Ford 240 cubic inch gasoline engine while working as a member of a two (2) man team. He will use appropriate handtools, special tools, measuring instruments and cleaning materials. All measurements will be recorded in appropriate spaces on Job Sheet and compared to manufacturer's specifications to determine extent of wear. All procedures will conform to manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".

Criterion Test: Measure engine parts and determine extent of wear according to job sheet.

3. Materials (consumable).
    a. Cleaning solvent.
    b. Engine oil.
    c. Wiping rags.
    d. Sweeping compound.

D. Training Aids and Devices:
  1. Film.
    a. MC-7889, "The Tools and Rules for Precision Measuring" (30 min.).
  2. Locally Prepared Materials.
    a. Information Sheets.
      (1) CM "A" IS 1.2.4.1, "Measuring Instruments".
      (2) CM "A" IS 1.2.4.2, "Fractions".
      (3) CM "A" IS 1.2.4.3, "Conversion Chart".
    b. Job Sheet.
      (1) CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".
    c. Work Sheet.
      (1) CM "A" WS 1.2.4.1, "Mathematics Work Sheet".

E. Training Aids Equipment:
  1. 16mm sound movie projector.

Homework: Read Automotive Mechanics, 6th edition, chapters 17, 18 and 19.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. **Name:**		
2. **Topic: Inspection and Measuring of Engine Parts.**		
B. Establish readiness.	**I.B. Motivate student.**	
1. Purpose.		
2. Assignment.		
C. Establish effect.	**I.C. Bring out need and value of material being presented.**	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	**I.D. State learning objectives.**	
	1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Mathematics.	II.A. Issue information sheet CM "A" IS 1.2.4.1, "Fractions". Have students turn in complete work sheet, CM "A" WS 1.2.4.1, "Mathematics Work Sheet, Decimals".	II.A. Follow instructo discussion and take not
1. Conversion of decimals to fractions:	II.A.1. Solve problems using chalkboard to enable students to see all steps of solution.	
a. Write decimal as common fraction.		
(1) Digits of decimal fraction become numerator without decimal point.		
(2) Denominator is 1 followed by as many zeros as there are digits behind decimal point.		
b. Reduce to lowest terms by dividing both numerator and denominator by the same number.		
EXAMPLE: Convert .625 into common fraction. $.625 = \frac{625}{100}$ second, reduce to lowest terms $\frac{625}{1000} \div \frac{5}{5} = \frac{125}{200}$ $\frac{125}{200} \div \frac{5}{5} = \frac{25}{40}$ $\frac{25}{40} \div \frac{5}{5} = 5/8$	NOTE: Call on students by name for steps in solving problems.	Participate in solving mathematics problems as called on by instruc tor.

PROBLEM: Convert .0625 to common fraction.

$$.0625 = \frac{625}{10000}$$

$$\frac{625}{10000} \div \frac{5}{5} = \frac{125}{2000} \div \frac{5}{5} = \frac{25}{400} \div \frac{5}{5} = 5/80$$

$$5/80 \div \frac{5}{5} = 1/16$$

PROBLEM: Convert .1250 into common fraction.

$$.1250 = \frac{1250}{10000} \div \frac{10}{10} = \frac{125}{1000} \div 5/5 = \frac{25}{200} \div \frac{5}{5} = \frac{5}{40}$$

2. Conversion of common fraction to decimal.

   a. Divide denominator into numerator being sure to place decimal correctly.

EXAMPLE: Convert 3/4 to decimal.

Divide denominator into numerator.

$$3/4 = 4\overline{)3} = .75$$

$$\begin{array}{r} 0.75 \\ 4\overline{)3.00} \\ \underline{2\ 8} \\ 20 \\ 20 \end{array}$$

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

PROBLEMS: Convert the following fractions to decimals: 5/16, 7/8, 5/8.

```
                0.3125
5/16 = 16/5.0000
          4 8
            20
            16
             40
             32
             80
```

```
             0.8750
7/8 = 8/7.0000
        6 4
          60
          56
           40
           40
            0
```

```
             0.6250
5/8 = 8/5.000
        4 8
          20
          16
           40
           40
```

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Micrometer caliper. 1. Nomenclature of the micrometer caliper.	II.B. Show movie: MC7889, "The Tools and Rules for Precision Measuring" (30 min.).	II.B. View movie and take notes.
	Review high points of movie.	Follow instructor discussion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Composed of 5 major parts. (1) Frame. (2) Barrel. (3) Anvil. (4) Spindle. (5) Thimble.	II.B. Cont'd. Issue training aid calipers.	
2. Method of correcting micrometer zero setting. a. Use standard. b. Allow for correction. (1) Zero setting method will vary with a different make of micrometer. Usually done by senior P.O. assigned to the machine shop.	II.B.2. Direct students to set micrometers on various settings to provide practice and experience in reading micrometer scales.	II.B.2. Accomplish micrometer settings as directed by instructor.
3. Reading the settings of the micrometer caliper. a. Determine the inch size of micrometer frame. b. One numbered barrel division represents .100 of an inch. c. One barrel division between the numbered divisions represents .025 of an inch.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Beveled edge of thimble's circumference is divided into 25 divisions.		
(1) Each division represents .001 of an inch.		
(2) One complete revolution of the thimble equals 1/40 of an inch or .025.		
4. Measuring diameters.		
a. Steps to be taken before measuring.		
(1) Clean surface to be measured.		
(2) Clean faces of spindle and anvil.		
(3) Check spindle for free turning.		
(4) Check micrometer for accuracy.		
b. Measure front and rear of journal for taper.		
(1) Measure diameter at three (3) positions.		
C. Calipers.	II.C. Have students refer to Automotive Mechanics, 6th edition, McGraw-Hill text, pp. 41, 42 and 43 to view illustrations showing correct use of measuring instruments.	II.C. Refer to pages in text as directed b instructor.
1. Inside calipers.		
a. Checks internal measurements.		

(1) Measurement must be read with aid of a rule.

(a) Instructor demonstrate.

2. Outside calipers.

3. Taking measurements with calipers.

D. Thread gauges.

1. National course (U.S.S.) United States Standard.

2. National fine (S.A.E.) Society of Automotive Engineers.

3. Method of checking threads with gauges (mention depth) etc.

a. Used to find number of threads per inch (pitch).

(1) Instructor demonstrate.

E. Thickness gauges (feeler gauges) and step gauges.

1. Used to check very small clearances between two flat surfaces.

F. Spark plug gap gauges.

1. Advantages of round gauge over flat gauge.

a. Flat feeler may not measure point opening if used on roughened points as accurately as a round gauge.

2. Use of spark plug gauge.

   a. To provide spark plugs with an accurate air gap between electrodes.

G. Miscellaneous measuring instruments.

1. Rulers.

   a. Common rule.

      (1) Calibrated in inches and common fractional parts.

   b. Decimal rule.

      (1) Calibrated by increments of tenths.

   c. Tape rule.

      (1) Same as common rule, except that it is flexible, and may be rolled up.

   d. Folding rule (carpenter's rule).

      (1) Same as common rule, except that it may be folded.

2. Telescoping gauges.

   a. Used to measure inside dimensions with the aid of an outside micrometer.

NOTE: When transferring reading from telescope gauge to outside micrometer, don't squeeze micrometer down too tight or reading will change.

3. Inside micrometer.

   a. Used to measure inside dimensions without the aid of an outside micrometer.

4. Depth micrometer.

   a. Calibrated same as micrometer caliper.

      (1) Calibrations progress in reverse direction.

5. Dial indicators.

   a. Has a contact point that bears against a shaft or rod to check its alignment and wear.

   b. The common dial indicator has a dial that's graduated in thousandths of an inch - both plus and minus.

H. Importance of accuracy.

1. Quality and efficiency of work performed.

2. Extent of repairs needed.

I. Care of measuring instruments.

OUTLINE OF INSTRUCTION

1. These are precision tools and must receive utmost care.
    a. Protect from rust.
    b. Protect from lint.
    c. Avoid mechanical damage.
    d. Keep clean and lightly oiled, dip in kerosene let drip dry.

J. Cleaning of engine parts.

NOTE: This portion of this presentation will be conducted by student participation in the actual disassembly of the 6 cylinder gasoline engine in accordance with attached "Job Sheet" and instructor supervision.

NOTE: Because this is "A" level training, the below portion of this topic should be kept brief and be lecture, discussion and demonstration.

INSTRUCTOR ACTIVITY

NOTE: Oral questions.

1. How is a journal measured to determine taper?

2. What steps should be taken before measuring with a micrometer?

3. Name the 5 major parts of a micrometer.

4. Why is a round gauge used to measure spark plug gap?

STUDENT ACTIVITY

NOTE: Answer questions as called on by instructor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
K. Inspection and measurement.		
1. Use of precision measuring tools.		
2. Determining wear replacement needs as per manufacturer's limits.		
3. Compiling parts list and use of parts books.		
L. Reconditioning engine parts (demonstration).	II.L. Demonstrate use of valve reconditioning equipment.	II.L. Follow instructor demonstration and take notes.
1. Reface valves.		
2. Reface valve seats.		
M. Bearing replacements.		
1. Main.		
2. Connecting rod.		
III. Application.		
A. Measure engine parts and determine extent of wear according to job sheet.	III.A. Direct supervise and evaluate student performance in measuring engine parts and determining extent of wear.	III.A. Measure engine parts and determine extent of wear accordi to job sheet.
IV. Summary.		
A. Conversion of decimals to fractions.	Issue CM "A" IS 1.2.4.3, "Conversion Chart".	
B. Micrometer caliper.		
C. Calipers.		
D. Thread gauges.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
E. Thickness gauges.		
F. Spark plug gap gauges.		
G. Miscellaneous measuring instruments.		
H. Importance of accuracy.		
I. Care of measuring instruments.		
J. Cleaning of engine parts.		
K. Inspection and measurement.		
L. Reconditioning.		
M. Bearing replacements.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Gasoline Engine Assembly

Average Time: 2 Periods (Class), 8 Periods (Pract)

Instructional Materials:

A. Texts:

1. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., chapters 20, 21 and 22.
2. 1969 Ford Truck Shop Manual, Vol. 2, pp. 08-04-26, 27, 08-04-11, 12, 13, 14.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.
    a. Shop tools.
    b. Hand tools.
2. Equipment:
    a. Major.
        (1) Ford, 6 cylinder gasoline engine (12 each).

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly" and CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment". Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of 37° - 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Enabling Objectives: Upon completion of this topic each student will be able to assemble a six cylinder gasoline engine while working as a member of a two (2) man team, using a Ford, 240 cubic inch engine. He will use all appropriate handtools, special tools, shop equipment and materials. The task will be accomplished while conforming to manufacturer's specifications without deviation as specified in Job Sheet CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly.

3. Materials (consumable).

   a. Ford engine gasket sets.

   b. Cleaning solvent.

   c. Engine oil.

   d. Wiping rags.

   e. Chassis grease.

   f. Gasoline.

   g. Sweeping compound.

   h. Miscellaneous engine parts.

D. Training Aids and Devices.

1. Locally Prepared Material.

   a. Job Sheet.

      (1) CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly".

E. Training Aids Equipment: None.

Criterion Test: Assemble a 6 cylinder gasoline engine while working as a member of a two student team using appropriate handtools, special tools, shop equipment and materials, conforming without deviation to manufacturer's specifications as specified on job sheet.

Homework: Read Automotive Mechanics, 6th edition, McGraw-Hill Book Co., chapters 20, 21 and 22.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Gasoline Engine Assembly		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives. 1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Engine assembly. 1. Routine procedures. a. Oiling of parts.	II.A. Stress the importance of cleanliness of engine parts and mating surfaces.	II.A. Assemble clean, well oiled parts as specified in job sheet and directed by instru tor.
b. Proper safety locking of parts. c. Following of manufacturer's specifications.	Ascertain that all precision surfaces are well oiled before assembly.	
d. Common rules for tolerances. 2. Checking bearings.	Insure that proper torquing procedure is followed and that manufacturer's specifications are complied with.	Torque assemblies as per manufacturer's specifications using proper torquing techniques.
a. Cause of bearing failures. b. Methods of determining excessive bearing wear and clearance. (1) Use of plastigage. (2) Use of micrometers and special measuring instruments. c. Methods of correcting excessive bearing clearance. (1) Replacement of inserts. 3. Assembling cylinder head. a. Installation of valves. b. Mounting of cylinder head.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Tightening procedure.		
4. Prestart checks.	II.A.4. Encourage students to ask questions when in doubt.	II.A.4. Conduct prestart checks.
a. Fuel, oil and water lines.		
b. Gaskets.		
c. Fan belt.		
d. Lube oil supply.		
e. Water supply.		
f. Electrical connections.		
g. Engine mountings.		
h. Adjustment of valve lash.		
i. Ignition timing.		
5. Operating checks and adjustment:	II.A.5. Instructor conduct initial starting of engine.	II.A.5. Conduct operational checks by monitoring instruments
a. Oil pressure check.		
b. Temperature check.		Report any unusual noises to instructor immediately.
c. Charging rate check.		
d. Final valve adjustment.		
e. Carburetor adjustment.		
(1) Air adjustment.		
(2) Idle adjustment.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application:		
A. Assemble a 6 cylinder gasoline engine while working as a member of a two man team using appropriate handtools, special tools, shop equipment and materials, conforming without deviation to manufacturer's specifications as specified in Job Sheet.	III.A. Direct, supervise and evaluate student performance in assembling a 6 cylinder gasoline engine.	III.A. Assemble a 6 cylinder gasoline engine while working as a member of a two man team using appropriate handtools, special tools, shop equipment and materials, conformi to manufacturer's specifications without deviation as specified in the Job Sheet.
IV. Summary.		
A. Engine assembly.		
1. Routine procedures.		
2. Checking bearings		
3. Assembling cylinder head.		
4. Prestart checks.		
5. Operating checks and adjustments.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Gasoline Engine Trouble, Diagnosis and Adjustment

Average Time: 10 Periods (Class), 15 Periods (Pract)

Instructional Materials:

A. Texts:

1. Automotive Mechanics, 6th edition, McGraw-Hill Book Co., pages 337 - 389.
2. 1969 Ford Truck Shop Manual, Volume 2, Groups 8 and 13.
3. 1969 Ford Truck Shop Manual, Volume 3, Groups 14 and 15.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.
   - a. Automotive shop tools.
   - b. Automotive handtools.
2. Equipment.
   - a. Major.

Terminal Objective: Upon completion of this unit each student will be able to disassemble, assemble, tune and adjust a six cylinder gasoline engine using a Ford, 240 cubic inch engine. Using appropriate handtools, shop equipment and materials, he will accomplish this task in accordance with Job Sheets CM "A" JS 1.2.3.1, "Gasoline Engine Disassembly, Inspection and Assembly" and CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment". Upon completion of assembly and tune-up, the engine shall perform with an ignition timing of 6° B.T.C., dwell of 37° - 42°, idle at 550 rpm, intake manifold of 18 - 21 inches, oil pressure and coolant temperature in normal operating range.

Enabling Objectives: Upon completion of this topic each student will be able to test, tune and troubleshoot a six cylinder gasoline engine using a Ford, 240 cubic inch engine. He will use appropriate handtool and test equipment. All performance will conform to procedures established by Job Sheet CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment". The engine will be tuned to meet manufacturer's specificatio as to ignition timing of 6° B.T.C., dwell 37° to 42°, idle speed 550 rpm and intake manifold vacuum of 18 - 21 inches. His performance will comply with job sheet procedures without error.

  - (1) Ford, 6 cylinder gasoline engines (12 each).

3. Materials (consumable).
   - a. Cleaning solvent.
   - b. Engine oil.
   - c. Miscellaneous engine parts.
   - d. Wiping rags.

4. Test equipment.
   - a. Battery starter tester (6 each).
   - b. Tach-dwell meter (12 each).
   - c. Timing light (12 each).
   - d. Compression tester (12 each).
   - e. Vacuum gauge (12 each).
   - f. Cooling system pressure tester (12 each).
   - g. Battery hydrometer (12 each).

D. Training Aids and Devices:

1. Charts.
   - a. 6002 - Gasoline Engine Diagnosis, Ford Service Publications, P.O. Box 7750, Detroit, Michigan 48207.

Criterion Test: Tune a 6 cylinder gasoline engine to meet manufacturer's specifications as to ignition timing, dwell angle, idle speed and manifold vacuum.

Homework: Read Automotive Mechanics, 6th edition, pages 337 - 389.

2. Locally Prepared Materials:

   a. Job Sheet.

      (1) CM "A" JS 1.2.6.1, "Gasoline Engine Diagnosis and Adjustment".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Gasoline Engine Trouble Diagnosis and Adjustment.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives.	
	1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Battery maintenance.	II.A. Have students refer to Automotive Mechanics, 6th edition, pages 337 - 344 to follow battery maintenance procedures.	II.A. Refer to pages of text as directed by the instructor.
1. Cleaning.		
a. Use bristle brush on top of battery.		
b. Use acid neutralizer.		
(1) Baking soda and water.		
c. Use of terminal brushes.		
2. Inspecting.		
a. Case.		
(1) Check for bulging and cracks.		
b. Connections.		
(1) Check for looseness and corrosion.		
c. Hold-downs.		
(1) Check for being too loose or too tight.		
d. Water level.		
(1) Check for proper level.		
(a) Should be 3/8" above plates, if no indicator is used.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Testing. a. Specific gravity. (1) Correct use of hydrometer. (a) Hold in vertical position. (b) Draw in electrolyte until float rises. (c) Taking reading at eye level. (d) Record reading along with temperature of electrolyte. (e) Make temperature correction. 1. Add four points (.004) for every 10°F above 90°F. 2. Subtract four points (.004) for every 10°F below 90°F.	II.A.3. Demonstrate battery tests using hydrometer and battery starter tester.	II.A.3. Observe demonstration and take notes.
b. Individual cell test (if battery construction permits). (1) If cell falls below voltage of 1.5 or if there is a difference of more than .2 volt between cells, recharge.	II.A.3.b. Have student conduct battery tests.	II.A.3.b. Conduct hydrometer test and battery capacity test.

OUTLINE OF INSTRUCTION

4. Charging.
   - a. Constant potential (voltage).
     - (1) Batteries connected in parallel.
   - b. Constant current.
     - (1) Batteries connected in series.

5. First aid and safety precautions.
   - a. Acid burns.
     - (1) Always wear protective clothing.
       - (a) Goggles or face shield.
       - (b) Rubber apron.
       - (c) Rubber gloves.
     - (2) If one of your men is burned by acid, keep calm and apply first aid.
       - (a) Douse burned area with large amounts of water.
       - (b) Apply a solution of baking soda and water or ammonia and water.
       - (c) Check into nearest dispensary for further treatment.

INSTRUCTOR ACTIVITY

II.A.4. Explain operation of constant potential charging and constant current charging systems.

NOTE: Take class to shop.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Electric shock.		
(1) Treat all electrical circuits as hot circuits.		
(2) If someone suffers electric shock, try to keep calm.		
(a) De-energize circuit, then release victim from contact.		
(b) Begin artificial respiration if victim is not breathing.		
(c) Keep victim quiet after normal breathing is re-established.		
(d) Treat for shock.		
(e) Treat burns.		
(3) Call for medical attention as soon as conditions permit.		
B. Inspection of cranking system components.	II.B. Direct class to remove batteries from training aid engines.	II.B. Remove batteries from training aid engines and place on bench.
1. Check connections and wiring.		
a. At motor terminal.	Place batteries on charge and adjust charging rate.	Observe hook-ups and setting of charging rate.
b. At solenoid or magnetic switch terminal.		
	Demonstrate voltage drop test of cranking system.	Observe demonstration and take notes.
		Conduct voltage drop test of cranking system

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Check for frayed and broken wire.		
(2) Check for cracked and worn insulation.		
c. At battery terminals.		
2. Motor brushes.		
a. Check for worn brushes.		
b. Check brush spring holders.		
(1) For looseness, distortion, etc.		
3. Controls.		
a. Check for corroded and loose terminals.		
(1) Magnetic switch.		
(2) Solenoid.		
C. Cranking motor maintenance.	II.C. Demonstrate cranking motor maintenance.	II.C. Conduct crankin system maintenance.
1. Servicing of commutator and brushes.		
a. Check for burned commutator bars.		
(1) Clean with "00" sandpaper.		
b. Replace brushes if less than half original length.		
2. Check bendix for freeness.		

OUTLINE OF INSTRUCTION

3. Check over-running clutch for slippage.
    a. Check for rough turning pinion.
4. Clean and oil drive mechanism.

D. Servicing A.C. charging system (alternator).
1. Wiring and connections.
    a. Check wiring and connections for corrosion and breaks.
2. Drive belt.
    a. Improper adjustment and alignment.
        (1) Adjust to manufacturer's specifications.
        (2) Ensure pulley alignment is correct.
            (a) Reduce belt flexing.

E. Regulators.
1. Removal and replacement:
    a. When defective and not operating correctly.
2. Polarization: (D.C. charging system).
    a. Standard-duty generators (Circuit "A").

INSTRUCTOR ACTIVITY

II.D. Point out that alternator requires very little maintenance except for clean, tight connections and proper belt tension.

NOTE: Emphasize these A.C. cautions:

1. DO NOT ground the field circuit with the ignition switch turned "ON", this will blow the fuse wire in the regulator and could ruin it.

2. DO NOT operate engine with battery disconnected. DO NOT attempt to polarize an alternator. This could seriously damage the equipment.

STUDENT ACTIVITY

Participate in discussion and take notes.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(1) Polarize before starting engine.

(2) Connect jumper wire to battery terminal of the regulator and touch or strike the other end to the armature terminal of regulator.

b. Heavy-duty generators (Circuit "B").

(1) Polarize before starting engine.

(2) Disconnect field lead from the field terminal of regulator and touch or strike the battery terminal of regulator.

F. Servicing D.C. generator.

1. Worn or broken brushes.

a. Replace if broken or worn more than half the original length.

2. Seating of new brushes.

a. Make sure brushes have at least 50% contact.

b. Use sandpaper or seating stone.

3. Armature and bearings.

a. Worn shaft and bearing.

(1) Inspect for alignment and wear.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Replace shaft and bearings.		
b. Loose or damaged windings.		
(1) Replace armature and shaft.		
G. Inspection and servicing the ignition system.	II.G. Have class refer to Automotive Mechanics, 6th edition, chapter 15 for view illustrations showing service points of ignition system.	II.G. Refer to pages in text as directed by instructor.
1. Battery, cables and terminals.		
a. Check for:		
(1) Battery condition.		
(a) Specific gravity and voltage of cells.		
(2) Broken, loose or corroded terminals.		
2. Ignition coil.		
a. Corroded terminals.		
(1) If found clean - make tight.		
b. Cleaning of high tension terminal socket.		
(1) Use special wire brush designed for this job.		
c. Replacement of faulty coil.		
(1) According to manufacturer's specifications.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

3. Distributor.

   a. Preliminary check of centrifugal advance mechanism.

      (1) Check for:

         (a) Weak springs.

         (b) Sticking advance weights.

      (2) Cleaning of sticking weights.

         (a) Remove and use solvent in cleaning.

   b. Checking and servicing vacuum advance.

      (1) Check for:

         (a) Leaking diaphragm.

         (b) Broken springs.

         (c) Replace a faulty vacuum advance mechanism if trouble cannot be corrected.

   c. Breaker points.

      (1) Replacement of points.

         (a) Burned and pitted points.

         (b) Incorrect spring tension.

         (c) Alignment of points.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

d. Condenser.

  (1) Replacement of faulty condenser.

    (a) Check manufacturer's specifications for proper condenser to use.

e. Distributor cap and rotor.

  (1) Inspect cap for cracks.

  (2) Inspect and clean terminals.

  (3) Inspect rotor for cracks and corrosion.

f. Distributor timing:

II.G.3.f. Demonstrate distributor service and timing.

  (1) Removal and installation of distributor.

    (a) Varies between engines, check manufacturer's manual.

  (2) Wiring of distributor.

    (a) Check manufacturer's specifications or manual.

  (3) Timing distributor.

    (a) Varies considerably, check manufacturer's specifications.

OUTLINE OF INSTRUCTION

(4) Checking distributor timing using stroboscopic timing light.

(a) Varies with different engines, check manufacturer's manual.

g. Spark plugs.

(1) Removal.

(a) Use proper spark plug tool.

(2) Inspection.

(a) Check for burning, carbon, cracked, porcelain, etc.

(3) Cleaning and testing.

(a) Use spark plug cleaner.

(4) Gapping and installation.

(a) Use wire-type spark plug gauge.

(b) Tighten to cbtain good seal.

H. Engine test and tune-up.

1. Normalizing engine temperature.

2. Check of instruments.

a. Oil pressure.

INSTRUCTOR ACTIVITY

II.H. Have students refer to Automotive Mechanics, 6th edition chapters 26 and 27 covering trouble-shooting and tune-up.

Direct student practice in engine tune-up.

STUDENT ACTIVITY

Practice tuning Ford 6 cylinder gasoline engine.

(1) If oil pressure does not come up, secure engine immediately.

b. Charging rate.

(1) Should show a charge, if not, secure engine, check battery cables and polarize.

c. Engine temperature.

(1) Should rise to near normal reading.

3. Compression test.

a. Removal of all spark plugs.

b. Compression test (dry).

(1) Procedure.

(a) Open throttle to widest position.

(b) Open choke.

(c) Apply tester to spark plug hole.

(d) Turn engine using starting motor.

(e) Gauge dial will register compression.

(f) Check all cylinders.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(2) Recording of reading.

(a) Record for comparison.

c. Compression test (wet).

(1) Employ oil-check method.

(a) If more than ten pounds variation between cylinders.

(2) Recording of readings.

(3) Comparison with dry readings.

d. Interpreting readings:

(1) Faulty valves.

(a) If low reading with oil-check; indicates valves.

(2) Faulty rings and/or cylinders.

(a) If oil-check raises reading considerably; indicates piston rings.

(b) Low reading on two adjacent cylinders; may indicate blown head gasket.

4. Vacuum tests:

a. Steady and fairly high (18 to 21 inches).

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(1) Normal engine.

b. Steady and low indicates:

(1) Late ignition timing.

(2) Leakage around pistons and/or rings.

c. Very low indicates:

(1) Leaky intake manifold gasket.

(2) Leakage around valve stems.

d. Oscillations of needle increasing with engine speed indicates:

(1) Weak valve springs.

e. Gradual falling back toward zero, with engine idling indicates:

(1) Restriction in exhaust system.

f. Regular dropping back indicates:

(1) Valve stuck open.

(2) Plug not firing.

g. Irregular dropping back indicates:

(1) Sticking valves.

h. Floating motion or slow oscillation indicates:

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Rich fuel mixture.		
(2) Late valve timing.		
i. Racing of engine and quickly closing throttle.		
(1) If needle swings momentarily around 23 - 25 inches, compression is good.		
(2) Reading below 23 - 25 indicates possible trouble with rings, pistons or cylinders (valves).		
I. Diagnosing engine troubles.	II.I. Utilize chart 6002 to show trouble diagnosis.	
1. Engine will not turn over.		
a. Turn on head light switch.		
b. Close cranking motor switch.		
(1) Lights stay bright.		
(a) Open circuit between battery and starter.		
(2) Lights dim considerably.		
(a) Battery run down.		
1. Check with hydrometer.		
(b) Mechanical trouble in starter.		
1. Motor pinion may be jammed.		

(c) Mechanical trouble in engine.

1. Frozen.

a. Broken parts.

b. Lack of lubrication.

(3) Lights dim slightly.

(a) See if armature rotates when switch is closed.

1. Drive pinion may not be engaging.

2. Excessive resistance in circuit.

(4) Lights go out.

(a) Bad connection.

1. Probably at battery terminal.

(b) Lights burn dim or go out before starter switch is closed.

1. Battery has a low state of charge.

a. Check with hydrometer.

2. Engine turns slowly but does not start.
    - a. Battery may be in low state of charge.
        - (1) Check with hydrometer.
    - b. Cranking motor defective.
    - c. Mechanical trouble in engine.
3. Engine turns over normally but does not start.
    - a. Battery and cranking motor satisfactory.
    - b. Trouble in ignition system.
        - (1) Check by holding a plug wire 3/16" from block while cranking.
            - (a) Spark occurs, ignition system is normal.
            - (b) No spark occurs, ignition trouble.
    - c. Trouble in fuel system.
        - (1) Try priming engine.
            - (a) Starts, but does not continue to run.
                - 1. Check fuel pump delivery.

(b) Does not start, valve action may be faulty.

(2) Automatic choke may be inoperative.

(a) Choke should be open on hot engine.

(b) Choke should be closed on cold engine.

4. Engine runs but misfires.

a. Locate missing cylinder by shorting one spark plug at a time.

b. Check spark at missing cylinder.

(1) Weak or no spark indicates:

(a) Defective insulation, cable or distributor cap.

(2) Good spark indicates possibility of bad plug.

(a) New plug fails to correct condition.

1. Cause probable valves.

5. Engine lacks power, acceleration and/or high speed performance.

a. Difficult to analyze since complaint is vauge.

b. Probable causes:

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(1) Ignition system causes:

  (a) Improperly timed.

(2) Fuel system might be cause.

(3) Restricted exhaust.

(4) Dragging brakes.

(5) Under inflated tires.

(6) Overheating.

(7) Defective automatic choke.

(8) Manifold heat-control valve not operating.

(9) Sticking valves.

6. Engine overheats.

a. Probable causes:

(1) Lack of coolant.

(2) Inoperative pump.

(3) Defective thermostat.

(4) Restricted radiator.

(5) Water jackets scaled over.

(6) Loose fan belt.

(7) Improper ignition timing.

(8) Lack of lubricating oil.

7. Rough idle.

a. Idle adjusting screw not properly set.

b. Dirty spark plugs.

8. High fuel consumption.

a. Same basic causes as engine lacks power, acceleration and/or high speed performance.

9. Engine pre-ignition or backfiring.

a. Probable causes.

(1) Improper ignition timing.

(a) Check with timing light.

(2) Carbon, sharp corners or other "hot spots".

(3) Extremely hot valves.

J. Engine noises:

1. Valve and tappet noises.

a. Caused by excessive clearances.

(1) Adjust to specifications.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

2. Spark knock.

    a. Pinging or clattering noises.

        (1) Most noticeable during acceleration.

    b. Probable cause.

        (1) Advanced timing.

        (2) Fuel with low-octane rating.

3. Connecting rod noise.

    a. Light knocking or pounding noise.

        (1) Most noticeable at high RPM's, no load.

    b. Can be pinpointed by shorting out one plug at a time.

    c. Probable causes.

        (1) Worn bearing or crankpin.

        (2) Excessive bearing clearance.

4. Piston pin noise.

    a. Similar to tappet noise.

        (1) Has characteristic double-knock.

    b. Most noticeable at idle.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

c. Probable causes:

(1) Worn or loose pin.

(2) Worn pin bushing.

5. Piston slap.

a. Muffled, hollow, bell-like sound.

b. If it occurs only with cold engine, it should not be considered serious.

c. If present at all times, further investigation is indicated.

d. Probable causes.

(1) Worn cylinder walls.

(2) Collapsed piston skirts.

(3) Excessive piston clearance.

6. Crankshaft knock (main bearings).

NOTE: Direct student practice in engine trouble-shooting.

NOTE: Practice engin trouble-shooting procedures as directed b instructor.

a. Heavy and dull metallic knock.

b. Most noticeable when engine is under heavy load or accelerating.

(1) Particularly audible when engine is cold.

c. Regular noise indicates worn main bearings.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Irregular noise probably due to worn thrust bearing.		
(1) This can cause noise to be most audible when clutch is engaged or disengaged.		
III. Application.		
A. Tune a 6 cylinder gasoline engine to meet manufacturer's specifications as to ignition timing, dwell angle, idle speed and manifold vacuum.	III.A. Direct, supervise and evaluate student performance during use of CM "A" JS 1.2.6.1.	III.A. Tune 6 cylind gasoline engine to meet manufacturer's specifications as to ignition timing, dwel angle, idle speed and manifold vacuum as specified in CM "A" J 1.2.6.1.
IV. Summary.		
A. Battery maintenance.		
B. Inspection of cranking system components.		
C. Cranking motor maintenance.		
D. Servicing A.C. charging system (alternator).		
E. Regulators.		
F. Servicing D.C. generator.		
G. Inspection and servicing the ignition system.		
H. Engine test and tune-up.		
I. Diagnosing engine troubles.		
J. Engine noises.		
V. Test:		
A. Written end-of-unit test.		

NAVAL CONSTRUCTION TRAINING CENTER
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CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Study Techniques

A. Benefits of good study techniques.

1. Economy of time and effort in the proper study habits.

2. Study techniques to help retain material taught.

B. Factors contributing to good study techniques.

1. Favorable environment.

a. Physical.

(1) Freedom from fatigue.

(2) Being physically fit.

(3) Being comfortable.

(4) No undue environmental distractions.

b. Mental.

(1) Material must have meaning.

(2) There must be a definite purpose or aim and the outcome must be worthwhile.

2. Regular study habits.

a. Place.

b. Time.

3. Improve concentration.

a. Resist distraction.

b. Read for specific purpose.

4. Improve reading ability.

    - a. Read carefully and thoughtfully.
    - b. Ask the question: "Do I understand what I've read?"
    - c. Practice increasing speed in reading.
    - d. Repetition.
        - (1) Overall thoughts.
        - (2) Sentences.
- 5. Have an outside interest such as sports, hobbies, etc.
- 6. Take an interest in what you are doing.
- 7. Readiness and interest for study.
- 8. Take notes.
    - a. Have a physical and mental attitude of attention.
    - b. Beware of taking too many notes.
    - c. Notes should be taken in an organized manner.
    - d. Take notes in a permanent legible form.
    - e. Review notes as often as possible.

C. Techniques in taking a test.

- 1. Preparing mentally.
    - a. Long range preparation.
        - (1) The best preparation for examinations consists in thorough day by day preparation. Light study and short rest before the examination will enable the student to attack the questions with least confusion and greatest clarity of mind.
    - b. Immediate preparation (cramming).
        - (1) Efforts to acquire in a few hours or days of frantic effort what should have been learned by systematic effort over a long period of time.
        - (2) Forgetting takes place rapidly once the examination has passed.

2. Preparing emotionally - "Test Nerves".

   a. Long range preparation with light study and much rest before examination will eliminate much anxiety.

3. Taking examinations in general.

   a. Understand purpose of examinations.

   b. Read and obey all rules and directions.

   c. Be there - be ready.

   d. Look over entire test quickly before answering any questions.

   e. Budget time.

      (1) Don't spend too much time on any given test item.

4. Objective, or short answer test.

   a. General hints for objectives type test.

      (1) Easy questions first.

      (2) Mechanical errors.

      (3) Changes - carefully consider changing an answer since first considerations are most generally correct. If change is desired, make sure erasures are complete avoiding possibility of two answers.

   b. Hints for true-false test items.

      (1) Know scoring rules.

      (2) Do not rely on patterns.

      (3) Be on guard for negative wording, the word "not" can change the entire meaning of the statement.

      (4) Do not be misled by partly false statements. If any part of the statement is false, the entire item is false.

   c. Hints for multiple choice test items.

      (1) Determine what is desired by the item.

      (2) Determine if correct answer is listed among choices.

   (3) If correct answer is not listed then select the most nearly correct statement.

 d. Hints for matching test items.

   (1) The suggested answer list will be less than the number of items in the question list.

   (2) Eliminate known items first.

5. Essay type examinations.

 a. Study the question.

 b. Briefly outline the answer before writing it.

 c. Write answer.

 d. Recheck answer.

6. Maintain own record of achievements for review.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Safety Policies

A. Safe handling and use of equipment.

1. Electrical.

    a. Good ground connection.

    b. Use proper cord, one capable of carrying enough current to operate the device you are operating.

    c. Use power tools within their rated capacity.

2. Fuels.

    a. Keep in closed well marked containers (safety cans).

    b. Store in area well away from open flames or operating equipment.

B. Safe handling and use of materials.

1. Proper lifting equipment.

    a. Use lifting equipment for heavy loads - hoists, jacks, chain falls, etc.

2. Proper moving equipment.

    a. Dollies, trucks, etc.

C. Personal safety indoors and out.

1. Tripping hazards.

    a. Door sills.

    b. Miscellaneous low equipment, etc.

2. Slipping hazards.

    a. Grease, oil, etc.

3. Eye hazards.
    a. Welding.
    b. Flying particles when grinding, hammering, etc.
    c. Mixing electrolyte.
4. Acids (sulfuric).
    a. Always pour acid into water.
    b. Wear protective clothing.
5. Toxic fumes.
    a. Keep spaces well ventilated.
6. Compressed air.
    a. Never play with air hose, practical jokes with an air nozzle can cause instant death or painful injuries.
    b. Keep nozzle pointed down away from eyes.

D. Avoiding and eliminating fire hazards.

1. Cleanliness.
    a. Keep floors, benches, etc. clean.
2. Proper stowage of material.
    a. Keep gasoline in closed gas cans.
    b. Use waste rag containers.
        (1) Never leave dirty or oily rags loose.

E. Methods of reporting accidents and fires.

1. Reporting procedures.
    a. Must be reported to the instructor even though no personal injury is incurred.
    b. Cause must be determined.
        (1) To prevent reoccurance of similar accidents.

2. Corrective action.

    a. First aid as required.

    b. Fighting fires as required.

        (1) Know the fire bill.

        (2) Know location of fire extinguishers and alarms.

F. Introduction to class safety man.

1. Point out and stress.

    a. Duties.

        (1) As outlined in NAVCONSTRACENINST 1510.1B.

    b. Responsibilities.

        (1) Ensure that students adhere to school safety policies and instructions AT ALL TIMES!!!!!!!!!

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Internal Combustion Engine Principles

A. Basic components and mechanical principles.

1. Cylinder and piston.

   a. The burning fuel - air mixture is trapped in the cylinder between the cylinder head and piston crown. Expansion of the burning gases forces the piston downward transmitting power to the connecting rod.

2. Connecting rod and crankshaft.

   a. The connecting rod changes the reciprocating motion of the piston to the rotary motion of the crankshaft.

3. Valves and operating mechanism.

   a. Intake valves - permit air and fuel mixture to enter cylinder during the intake stroke.

   b. Exhaust valves - permit the exhaust gases to escape during the exhaust stroke.

   c. Opening of exhaust and intake valves is accomplished by action of the camshaft through suitable linkage and closed by spring tension.

B. Engine operation.

1. Intake stroke.

   a. The piston moves down from T.D.C. creating a vacuum in the cylinder. The intake valve is open, so the mixture of gasoline and air rushes through the opening, pushed by atmospheric pressure outside.

2. Compression stroke.

   a. From its bottom position, bottom dead center (B.D.C.) the piston moves upward. The intake valve closes and the mixture is compressed in closed end of the cylinder. It is compressed or squeezed to a pressure of perhaps 200 lbs per square inch (PSI).

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3. Power stroke.

   a. The spark occurs, the burning mixture expands, and almost immediately the pressure jumps to 600 to 700 PSI three or four times the pressure before ignition. With a piston 3 1/2 inches in diameter, the total pressure on the top will be about three (3) tons. This enormous force pushes the piston down, which of course makes the crankshaft turn, delivering power to what ever is connected to the shaft.

4. Exhaust stroke.

   a. Both valves have been closed during the compression and power stroke, but now the exhaust valve opens. As the piston moves up again it forces the exhaust gases out through the passage opened by the exhaust valve. As the piston gets to the top, the exhaust valves close and intake valve opens again, ready for the beginning of the next cycle.

5. Engine timing.

   a. Valve timing.

      (1) The exact time in the engine cycle when the intake and the exhaust valves open and close in relation to piston travel.

         (a) Usually stated in terms of degrees of crankshaft rotation before and after TDC and BDC.

   b. Ignition timing.

      (1) The exact time the spark occurs in the engine cycle in relation to piston position.

C. Classification of engines.

1. By cooling systems.

   a. Air cooled.

   b. Liquid cooled.

2. By cylinder arrangements.

   a. In-line.

   (1) All cylinders cast in the straight line.

   b. V-type.

   (1) Two banks of cylinders mounted in a "V" shape above the crankshaft.

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c. Opposed or "flat" block.

(1) Cylinders mounted in two side rows, each opposite a central crankshaft.

3. By valve arrangement.

a. L-head.

(1) Both valves in block on the same side of cylinders.

b. I-head.

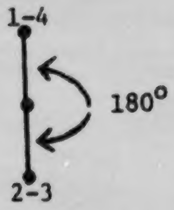
(1) Valves mounted in the head above the cylinders.

c. F-head.

(1) Intake valves located in the head, exhaust in the block.

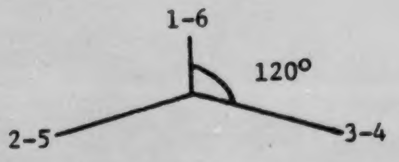
4. Crankshaft throw arrangements.

a. Four cylinder in-line.



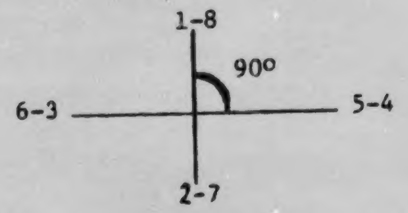
(1) 180° between throws; 180° between power impulses.

b. Six cylinder in-line.



(1) 120° between throws; 120° between power impulses.

c. Eight cylinder in-line.



(1) 90° between throws; 90° between power impulses.

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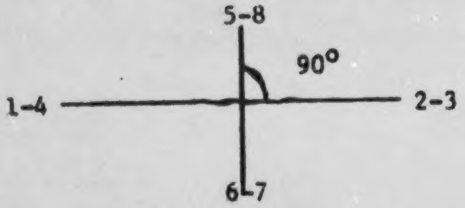
d. Eight cylinder V-type.



(1) 90° between throws.

5. Counter balances or counter weights.

   a. Used to dynamically balance the crankshaft.

   b. Located opposite the crankshaft throw to counter the weight of the crank throw and connecting rod.

   c. Usually forged integral with the crankshaft.

D. Components of gasoline engine fuel system.

1. Fuel tank - fuel storage.

2. Fuel filters - removes solids and collects water.

3. Fuel pump - delivers fuel to carburetors.

4. Carburetor - meters, atomizes and vaporizes fuel-air.

5. Intake manifold - distributes fuel/air to cylinders.

6. Fuel lines - transports fuels.

E. Carburetion principles.

1. Composition of air.

   a. Composed of 79 parts by volume of nitrogen, 21 parts of oxygen and traces of other gases.

   b. Air has weight.

      (1) About 14.7 lbs per square inch at sea level.

      (2) Pressure of air decreases with altitude.

2. Evaporation (vaporization).

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a. The term used to describe the action that takes place when a liquid changes to a vapor.

3. Atomization.

   a. The breaking up of the fuel into a fine spray consisting of tiny droplets of gasoline.

      (1) This exposes a large surface to air for rapid vaporization.

4. Venturi effect.

   a. Hour glass shape, creates low pressure area.

   b. Atmospheric pressure forces fuel from float bowl.

      (1) Air speed increases and pressure decreases.

F. Carburetor and circuits.

1. Float circuit.

   a. Controls fuel level in float bowl.

      (1) High fuel level causes.

         (a) Rich mixture.

         (b) Fuel too near end of discharge nozzle.

      (2) Low fuel level causes.

         (a) Lean mixture.

   b. Contains the following parts:

      (1) Needle valve and seat.

      (2) Float bowl.

      (3) Float.

      (4) Float bowl vent (external or internal).

2. Idle or low speed circuit.

   a. Delivers fuel at low engine speeds.

      (1) While idling at speeds up to 20 MPH (approx.).

   b. Operation.

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        (1) Low pressure area created by intake stroke.

        (2) Atmospheric pressure forces fuel through low speed circuit.

        (3) Delivers fuel below throttle valve.

    c. Basic parts of circuit.

        (1) Passage from float bowl.

        (2) Low speed jet.

        (3) Economizer.

        (4) Idle port.

        (5) Idle adjusting screw.

3. High speed, part load (circuit).

    a. Supplies fuel during change from low speed circuit to high speed circuit.

    b. During operation, the lowest pressure point changes from idle port to opening of high speed nozzle.

    c. Basic parts of circuit.

        (1) Venturi.

        (2) High speed nozzle.

        (3) Passage from float bowl.

4. High speed full power (circuit).

    a. Supplies fuel at speeds higher than 20 MPH.

    b. During operation, lowest pressure point will be at the high speed nozzle.

    c. Basic parts of circuit.

        (1) Venturi.

        (2) High speed nozzle.

        (3) Metering rod and jet.

    d. Types of high speed full power circuits.

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      (1) Mechanically operated.

      (2) Vacuum operated.

      (3) Combination mechanical and vacuum.

   NOTE: These circuits allow additional fuel to flow at high speed.

5. Accelerator pump circuit.

   a. Supplies additional fuel during rapid acceleration.

   b. Mechanically operated pump.

      (1) Linked to accelerator pedal.

         (a) Does not depend on atmospheric pressure.

   c. Basic parts of system.

      (1) Pump.

      (2) Inlet check valve.

      (3) Discharge check valve.

      (4) Jet.

6. Choke circuit.

   a. Provides rich mixture for starting cold engine and during warm up.

   b. Reduces opening through air horn, creating a lower than atmospheric pressure at main nozzle.

   c. Basic parts.

      (1) Choke valve.

      (2) Choke valve shaft.

      (3) Automatic or manual control.

G. Fuel pumps.

   1. Diaphragm non-positive displacement type (mechanical and electrical).

      a. Transfers fuel from tank to carburetor.

b. Construction and nomenclature of parts.

   (1) Rocker arm.

   (2) Diaphragm.

   (3) Diaphragm spring.

   (4) Inlet valve.

   (5) Outlet valve.

   (6) Fuel passages and chamber.

c. Inlet stroke.

   (1) Inlet valve opens, discharge valve closes.

   (2) Creates low pressure area in pump chamber.

   (3) Atmospheric pressure forces fuel into pump.

d. Return stroke.

   (1) Diaphragm spring tension moves diaphragm.

   (2) Forces fuel to carburetor.

   (3) Only delivers fuel when needle valve is off of seat.

e. Fuel filter.

   (1) On pumps with fuel filter service the same as any other fuel filter.

H. Intake manifolds.

1. Purpose.

   a. To direct the fuel and air mixture to the cylinders.

   b. Construction.

      (1) Straight and smooth as possible to reduce chances of condensation and reduce friction.

      (2) Heat control valve (heat riser).

         (a) To help promote better vaporization of the fuel by directing exhaust gases through a passage in the intake manifold thereby heating the base of the carburetor.

I. Exhaust manifold.

1. Purpose.

a. To carry exhaust gases away from the cylinders.

2. Construction.

a. Usually cast iron-free of unnecessary bends.

J. Lubrication system of components, purpose and function.

1. Oil pumps.

a. Are positive displacement.

b. Types.

(1) Gear type.

(2) Rotor type.

c. Principles of operation.

(1) Gears or rotors revolve forcing oil into pump cavity and around gears.

(2) Gear action causes pressure which forces the oil around the outside of each gear.

d. Relief and regulating valve.

(1) Prevents excessive pressure.

(2) Pump delivers more pressure than required then valve will open allowing excessive oil to return to oil pan.

2. Oil gauges.

a. Pressure gauge.

(1) Pressure expansion type.

(a) Bourdon tube.

(2) Electric type.

(a) Balancing coil.

(b) Bimetal thermostat.

3. Oil strainers.

a. Purpose.

(1) To remove large particles of dirt and sludge from oil before entering pump.

4. Oil filters.

a. Types of filters.

(1) By-pass filter.

(a) Part of oil to system and part to filter.

(2) Full flow filter.

(a) All oil passes through filter before entering system.

1. Employs a valve to by-pass filter if clogged.

5. Crankcase ventilators.

a. Breather tube method (road draft tube).

(1) Non-positive (obsolete).

b. Positive method (positive crankcase ventilation).

(1) Draws engine crankcase vapors by using intake manifold vacuum.

(2) (P.C.V.) valve must be cleaned at regular intervals (flow control valve).

c. Air pump system.

6. Types of lubrication systems.

a. Splash.

(1) Dippers on connecting rod bearing caps.

(a) Upon each revolution of crankshaft enter trays in oil pan.

(b) Dippers pick up oil, lubricating the connecting rod bearings and splashing oil in the form of a fine mist lubricating the following engine parts.

1. Valve train.

2. Wrist pins.

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3. Cylinder walls.

4. Piston rings.

(2) Oil pump provides oil from sump to trays.

b. Pressure feed.

(1) Oil is forced from sump to main oil gallery from there it lubricates the following:

(a) Main bearings.

(b) Connecting rod bearings.

(c) Cam shaft bearings.

(d) Wrist pin.

(e) Valve train.

(f) Cylinder walls (usually from spit holes in connecting rod).

c. Combination splash and pressure feed.

(1) Depends on both systems to adequately lubricate engine.

7. Types of cooling systems.

a. Gravity circulation (thermo-syphon).

(1) Utilizes theory that a warm liquid expands and loses weight and will rise, while a cool liquid will contract and gain weight and settle to the bottom.

(2) Obsolete and unpractical for high speed engines.

b. Forced circulation.

(1) Open cooling system.

(a) Marine cooling where lake or ocean water is circulated through the engine cooling system (outboard motor use).

(2) Closed cooling system.

(a) Radiator employed on autos, buses, trucks, tractors, etc.

(b) Heat exchanger - used on marine equipment - sea water is used to cool fresh water in cooling system.

c. Types of coolants.

(1) Water.

(a) Additives.

1. Rust inhibitor.

2. Anti-freeze.

(2) Permanent coolant.

(a) Factory installed.

d. Associated parts for typical automotive cooling systems.

(1) Radiator.

(a) Tabular type.

1. Vertical tubes for coolant flow.

2. Horizontal fins for heat transfer from tubes to cooling air.

(b) Honeycomb type (cellular).

1. Narrow water passages formed by pairs of thin metal ribbons.

2. Passages are separated by air fins also constructed of metal ribbon.

(2) Pressure caps.

(a) Purpose.

1. Permit build-up of pressure in cooling system to increase boiling point of coolant.

a. Each pound built-up raises boiling point about 3 1/4°F.

b. Blow off valve permits relief of excess pressure.

c. Vacuum valve admits air to enter cooling system while engine cools.

(3) Fan and shroud.

- (a) Fan (two to eight blades).
  - 1. Draws or blows air through radiator.
- (b) Shroud.
  - 1. Assures that all air moved by the fan passes through radiator.

(4) Thermostat.

- (a) Temperature sensitive valve.
  - 1. Placed inside water outlet of cylinder block.
  - 2. Regulates coolant temperature.
  - 3. With the thermostat closed, the water circulates entirely within the engine block thus warming up more rapidly.
  - 4. When the water becomes warm enough to open the thermostat, the water circulates through it into the radiator and thus normal cooling action is obtained.

(5) Water jackets.

- (a) Construction.
  - 1. Usually cast into the engine block and head.

(6) Temperature gauge.

- (a) Purpose.
  - 1. Warns operator of abnormal temperature rise.
- (b) Types.
  - 1. Electrical.
  - 2. Pressure (do not bend or kink pressure line).

(7) Water pump.

- (a) Forces coolant from radiator outlet hose through engine block.
- (b) Causes cooling system fluids to circulate within the system.
  - 1. Usually a centrifugal non-positive displacement type pump.

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NAVAL CONSTRUCTION TRAINING CENTER
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CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Maintenance of Lead-acid Storage Batteries.

A. Battery maintenance.

1. Cleaning.
    - a. Use bristle brush on top of battery.
    - b. Use acid neutralizer.
        - (1) Baking soda and water.
    - c. Use of terminal brushes.
2. Inspecting.
    - a. Case.
        - (1) Check for bulging and cracks.
    - b. Connections.
        - (1) Check for looseness and corrosion.
    - c. Hold-downs.
        - (1) Check for being too loose or too tight.
    - d. Water level.
        - (1) Check for proper level.
            - (a) Should be 3/8" above plates, if no indicator is used.
3. Testing.
    - a. Specific gravity.
        - (1) Correct use of hydrometer.
            - (a) Hold in vertical position.

(b) Draw in electrolyte until float rises.

(c) Taking reading at eye level.

(d) Record reading along with temperature of electrolyte.

(e) Make temperature correction.

1. Add four points (.004) for every 10° above 90°F.

2. Subtract four points (.004) for every 10° below 90°F.

b. Individual cell test (if battery construction permits).

(1) If cell falls below voltage of 1.5 or if there is a difference of more than .2 volts between cell, recharge.

4. Charging.

a. Constant potential (voltage).

(1) Batteries connected in parallel.

b. Constant current.

(1) Batteries connected in series.

B. First aid and safety precautions.

1. Avoid burns.

a. Always wear protective clothing.

(1) Goggles or face shield.

(2) Rubber apron.

(3) Rubber gloves.

b. If one of your men is burned by acid, keep calm and apply first aid.

(1) Douse burned area with large amount of water.

(2) Apply a solution of baking soda and water or ammonia and water.

(3) Check in to nearest dispensary for further treatment.

2. Electric shock.

   a. Treat all electrical circuits as hot circuits.

   b. If someone suffers electric shock, try to keep calm.

      (1) De-energize circuit, then release victim from contact.

      (2) Begin artificial respiration if victim is not breathing.

      (3) Keep victim quiet after normal breathing is re-established.

      (4) Treat for shock.

      (5) Treat burns.

      (6) Call for medical attention as soon as conditions permit,

Gas 240

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CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Basic Principles of Electricity

1. Nature of electricity.

   a. Electricity is the flow of electrons from atom to atom.

      (1) An atom is the smallest unit of all matter consisting of equal numbers of particles called electrons and protons.

         (a) Protons have positive (+) charge potential.

         (b) Electrons have negative (-) charge potential.

   b. Utilizing the electron theory we say electrons flow from the negative to positive terminals of a circuit.

2. Electrical circuits.

   a. A basic circuit consists of:

      (1) Voltage source - such as a battery.

      (2) Resistor/load - such as a light bulb.

      (3) Conductors - wire to connect the circuit components.

   b. The 3 types of complete circuits:

      (1) Series - one path for current to follow, this circuit has high resistance.

      (2) Parallel - Two or more paths for current to follow, this circuit has low resistance.

      (3) Series/Parallel - A combination of the above two, this circuit has medium resistance.

   c. Definitions of circuit failure.

      (1) OPEN - a break or interruption in a circuit such as a switch open, a wire loose from a connection or a blown fuse.

      (2) GROUND - when any part of a wiring circuit unintentionally touches the vehicle frame - normally contact between conductors and the iron frame or vehicle body.

      (3) SHORT - occurs when conductor touches conductor such as when the insulation between two wires fail and the wires touch.

3. Electricity - how it works.

   a. Amperage

      (1) Measurement of electron (current) flow, i.e. gallons per minute.

   b. Voltage

      (1) Measurement of the pressure used to make electrons move along a conductor.

   c. Resistance

      (1) Opposition to flow of electrons (current).

         (a) Resistance is directly related to 4 items.

            1 The length of the circuit.

            2 The size of the conductor.

            3 The material the conductor is made of.

            4 The temperature of the wire.

               a Electron flow generates heat. Proper circuit conductor size will pass off the required amount of heat and allow current to flow.

   d. Definition of conductors/insulators and semi-conductors:

      (1) Conductor - A material which will easily allow current to pass through it in either direction such as copper.

      (2) Insulator - Prevents the passing of current through it.

      (3) Semi Conductor - A material which is neither a good conductor or an insulator, but has a definite use.

         (a) Diode - An electrical device that will allow current to pass through it in one direction only.

            1 May be positive or negative.

         (b) Zener Diode - Will allow current to pass through it in one direction and only allow current above a specified voltage to flow in the reverse direction.

            1 Primarily used in control circuits.

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(c) Transistors - Controls the current in a circuit by either allowing or stopping it.

1 Polarity of transistors can be changed by the combining of different atomic weight materials in manufacture.

a Primarily used in transistorized regulators.

e. Magnetism

(1) A matter must have the ability of possessing a North and South Pole to be used as a magnet. (Rubber, wood, paper, glass do not possess this ability).

(a) Permanent magnets are: Matter which has had its magnetic particles alligned to give it a permanent North and South Pole.

1 Comes in many shapes but primarily bar and horseshoe and constructed of alloy steel.

(b) Electro-magnetism is: Electrons flowing thru a conductor. They will set up magnetic lines of force in a circle around the conductor. Circuit polarity has a definite relationship to the lines of force, as does the amperage flowing.

1 A simple electromagnet is constructed by placing a loop in the conductor. A usable electromagnetic is constructed by placing a soft metal bar through the center of the loop thus increasing the magnetic strength. Magnetic strength is further increased by increasing the number of turns (loops) around this bar. More turns using a smaller gauge wire will give a stronger electromagnet using lower amperage requirements on the primary side. Thus a 12V electro-magnet can do the same work as a 115V electro-magnet because of the number of turns and conductor size.

(c) Rules of magnetism:

1 Lines of force flow from north to south.

2 Magnetic lines of force never cross nor can they be insulated.

3 Like poles repel - Unlike poles attract.

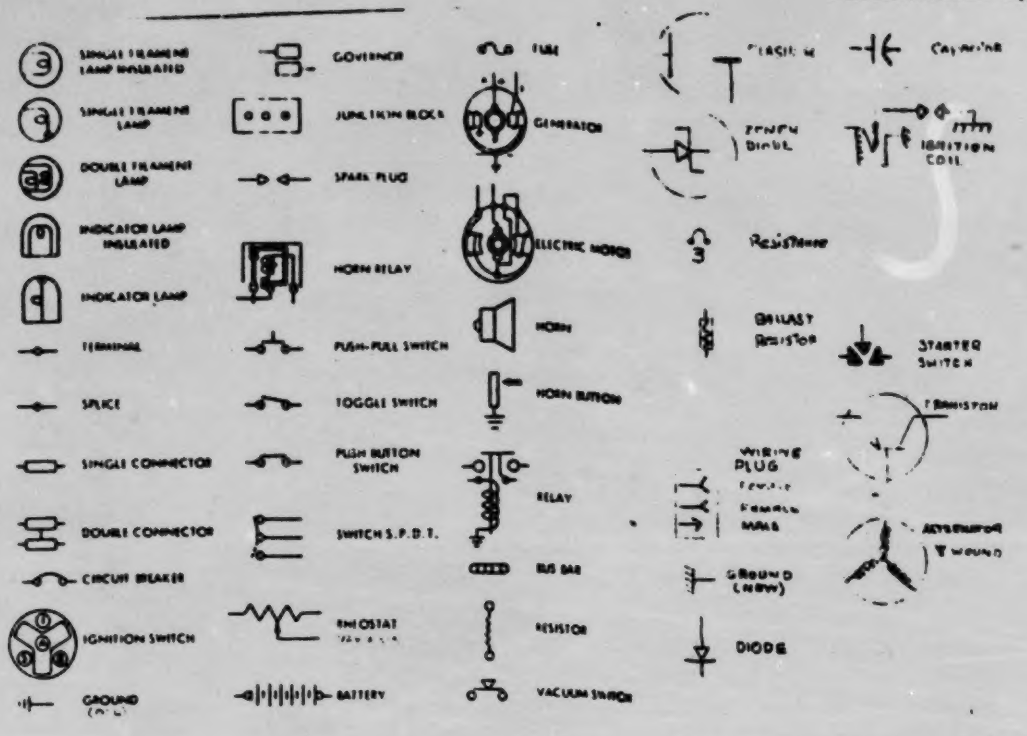
f. Electro-magnetic induction

(1) If a conductor is passed thru a stationary magnetic field, current will be induced to flow in this conductor (as in a D.C. Generator).

(a) The same induction can be accomplished by having a moving magnetic field and a stationary conductor as in an A.C. Generator (Alternator).

g. Electro-magnetic repulsion

(1) By introducing current into a conductor passing thru the stationary magnetic field we utilize the rule of magnetism "Like Poles Repell". This repulsion of the like poles cause the conductor to turn away. The turning away (rotary motion) is the principle of operation of a cranking motor.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SINGLE FILAMENT LAMP
DOUBLE FILAMENT LAMP
INDICATOR LAMP INSULATED
INDICATOR LAMP
TERMINAL
SPLICE
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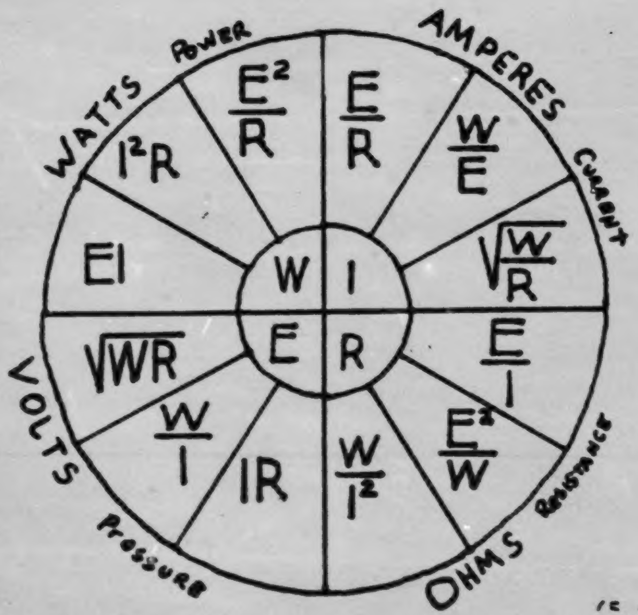
DOUBLE CONNECTOR
CIRCUIT BREAKER
IGNITION SWITCH
GROUND
GOVERNOR
JUNCTION BLOCK
SPARK PLUG
HORN RELAY
PUSH-PULL SWITCH
TOGGLE SWITCH
PUSH BUTTON SWITCH
SWITCH S.P.D.T.
RHEOSTAT
BATTERY
FUSE
GENERATOR
ELECTRIC MOTOR
HORN
HORN BUTTON
RELAY
BUS BAR
RESISTOR
VACUUM SWITCH
FLASHER
ZENER DIODE
Resistance
BALLAST RESISTOR
WIRING PLUG
FEMALE
FEMALE
MALE
GROUND (NEW)
DIODE
CAPACITOR
IGNITION COIL
STARTER SWITCH
TRANSISTOR
ALTERNATOR Y WOUND


WATTS
POWER
AMPERES
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OHMS
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EI
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IR
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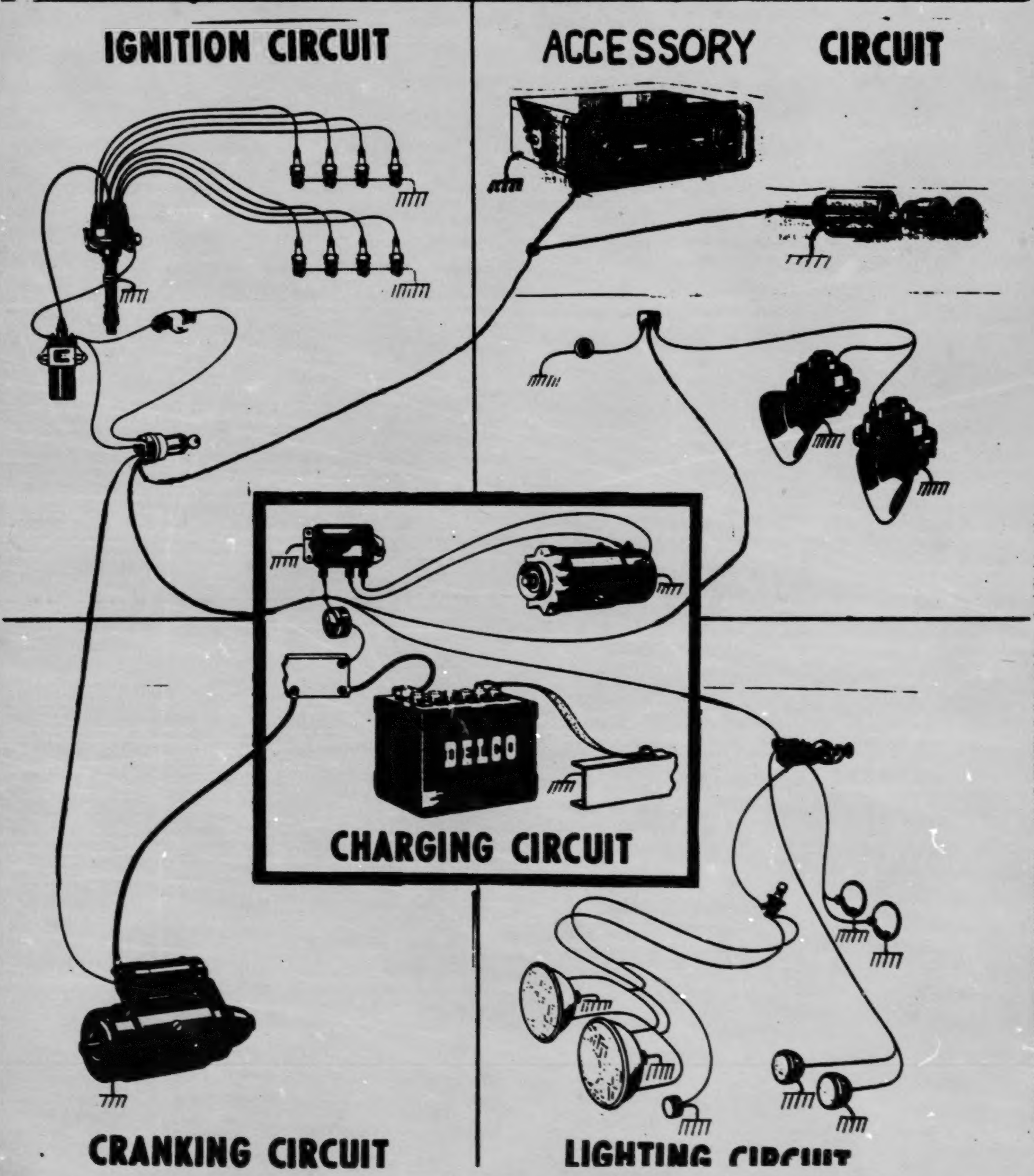
$\frac{E^2}{W}$
$\frac{E}{I}$

OHM'S LAW

I stands for amps (Intensity). E for volts (Electromotive force). R for ohms (Resistance) and W for watts (Power). Thus it's easy to compute any of these four values by Ohm's Law if you know at least two of them. For example: you buy a new toaster rated at 1100 watts. You want to find out how much current it uses Use the amperes section of the chart and pick out the formula that uses the two elements you know—wattage (1100) and voltage (115). Substituting in the formula $I = W \div E$ you get $I = 1100 \div 115$ or $I = 9.5$ amps. Where you want to find power, use the watts section of the chart and pick the two elements you know. $W = E \times I$.

ELECTRICAL SYSTEM


IGNITION CIRCUIT
ACCESSORY CIRCUIT
DELCO
CHARGING CIRCUIT
CRANKING CIRCUIT
LIGHTING CIRCUIT

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

GENERAL HOUSEKEEPING

1. Cleanliness.

a. Floors and other exposed areas.

The distribution center, garage, or workshop shall be thoroughly inspected daily and maintained in a clean and orderly state. Floors and other exposed surfaces shall be kept scrupulously clean. Hazards on floors such as oil, grease or loose tools, which might result in fire, slipping, tripping or falling shall be eliminated as quickly as possible.

b. Grease rack.

Particular care shall be taken to maintain cleanliness in the area around the grease rack as well as in the rack itself. Be sure that grease connections are fast to car connections when greasing a car. At the close of work each day, clean grease rack and floor.

2. Ventilation.

Garages and repair shops shall be well ventilated for protection of service personnel against accumulations of carbon monoxide. If these spaces are not equipped with adequate ventilation, doors shall be opened whenever engines are running.

3. Illumination.

Adequate illumination shall be provided and utilized for all general work areas, including work benches and lubrication pits.

4. Safety During Repairs.

Use warning signs or barricades to protect personnel when construction, repair work, or painting is in progress.

5. Avoiding Tripping Hazards.

Covers on sidewalk, boxes, fuel tanks, and pipe openings shall be flush with surfaces, and shall be kept closed when not in use. All tools and equipment shall be kept in their proper places when not in use and shall particularly be kept out of walkways to avoid tripping hazards.

PROTECTION OF PERSONNEL

The following personnel protective equipment shall be used by workmen is a distribution center, garage or workshop.

1. Apparel Required.

Mechanics shall wear goggles or face shields, rubber gloves, aprons, safety shoes, and special gloves as needed.

2. Goggles/Welding Goggles.

Goggles shall be worn for all grinding, welding, chipping, cutting and when using compressed air, or for similar operations designated by local commond. The object of tinted filter lenses in not only to diminish the intensity of visible light to a point where glare is reduced to a minimum so that the welding zone can be readily seen, but also to protect the welder from harmful infrared and ultraviolet radiation from the arc or flame.

3. Rings Prohibited.

Rings shall not be worn by workmen servicing batteries or working on motor vehicles.

FIRE PREVENTION

1. Fire-Fighting Apparatus.

Fire fighting apparatus shall be kept in proper working condition and well distributed with locations marked in accordance with NAVDOCKS P-309, "Application of Color to Shore Establishments". Garage personnel should be trained in the operation of this equipment.

2. Smoking.

Smoking or the carrying of lighted pipes, cigars, or cigarettes near fuel pumps, batteries on charge or vent pipes shall be prohibited.

EQUIPMENT AND TOOLS

1. General Rules.

a. Keep tools in their proper places when not in use.

b. Use only the correct tools for a particular job.

c. Never use defective tools.

d. Keep tools and hands free of grease. Clean tools with an approved solvent.

e. When using a bar on springs, work bar away from the face.

f. Lift small batteries with battery straps designed for this purpose. On large batteries use insulated lifting bridles designed for this purpose.

2. Blow Torches.

Blow torches shall not be used to clean crankcases, transmissions, radiators or grease guns; steam, hot water or other suitable degreasers shall be employed for this purpose.

3. Grease Guns.

Grease guns must be handled carefully and used only for the purpose intended. Serious injury has resulted when grease has been shot out of a grease gun in horseplay. NEVER point the gun toward another person.

4. Lube Dispenser.

Keep the dispenser where it will be out of the way, and check it at regular intervals for leaks.

5. Mobile Grease Cart.

The mobile grease cart must be returned to its proper place immediately after it is used, and the hose must never be left lying along the floor.

REPAIRING AND SERVICING VEHICLES

1. Body and Engine Work.

a. Entering the garage. When a car is being driven into a garage, personnel shall stand well out of its path. Never try to service a moving vehicle.

b. Securing the hood. Work shall not be started under a hood of a vehicle unless the hood has been firmly secured in the open position. Hood hold-down clamps or locking devices shall be kept in good condition. Additional hold-down clamps should be installed where necessary.

c. Broken glass. Care shall be taken to avoid injuries from broken windshield, light globes, lenses or jagged pieces of metal around the car.

d. Radiator. If the radiator is steaming, the hands should be protected with a large rag, and the steam allowed to escape before removing the cap entirely. Matches shall not be used when looking into a radiator.

e. Cranking the engine. If it is necessary to crank an engine by hand, the brake must first be set and the gearshift placed in neutral. In cranking, the handle should be grasped with the thumb alongside the fingers, and not around the crank. If possible, start the engine by a series of quick pulls. Spinning should always be started with an UPWARD PULL; never with a downward thrust.

f. Lifting heavy parts. To prevent personal injury when removing or replacing heavy parts, such as gear units or hub and drum assemblies, mechanics should always use a hoist, jack or dolly.

g. Restriction on leaded gasoline. Do not use gasoline containing tetraethyl lead for anything but motor fuel. If this type of gasoline is spilled on the body, wash it off thoroughly, as it is a deadly poison.

2. Vehicle Stands.

Approved metal vehicle stands shall always be used when work is being done under a vehicle from which the wheels have been removed. Wooden block or horses shall not be used for this purpose. Hydraulic lifts are permissible.

3. Dump Trucks.

Before starting repairs on a dump truck, with the dump body in a raised position, the body shall be secured by inserting the safety pins in the safety locks, or in the absence of such locks, the body shall be secured with sturdy blocking or trianglular steel stands designed for this purpose.

4. Working on Raised Vehicles.

a. Jacks.

(1) Inspection. Jacks shall be inspected visually for cracks, looseness, and wear. If there is any doubt about the condition of a jack, it must not be used.

(2) Blocking. Be certain that a vehicle is properly blocked when working under it. Do not depend entirely on jacks.

(3) Centering. Center the service jack on the axle when a wheel is to be removed from a car. The jack should always be set on a solid footing.

(4) Capacity. Never use a jack for a load in excess of its rated capacity.

(5) Handle. Place the jack so that the swing of its handle will be unobstructed. Never leave a jack standing under a load with the handle in the socket.

(6) Keeping clear. Never lean over a jack handle or handle socket under load. Keep the body clear of the car, in case it should suddenly start to roll.

b. Hydraulic Lifts.

(1) Inspection. Inspect hoists at regular intervals for oil leaks, oil level, and proper lubrication. Check overhead connections at regular intervals, and make frequent inspections of safety locks on gears; the teeth of gear locks should not be worn or chipped. Never use a defective hoist.

(2) Putting vehicle on lift. Do not stand in front of a hoist while a motor vehicle is being guided onto it.

(3) Securing vehicle. Never permit occupants to remain in a vehicle when it is to be lifted. Be sure, before lifting a vehicle, that the ignition is off, the gears are in neutral, the wheels are blocked and the doors are closed.

(4) Freewheel lift. If the freewheel type of lift is used, be sure the car is properly balanced. Raise the lift just enough to take the weight off the wheels, check the blocks and knee-action plates to determine whether the car is resting properly, and set the hand brake.

(5) Raising the hoist.

(a) When the hoist is raised, use the safety leg, and check to see that safety catches are secured.

(b) Never rock the car when the hoist is raised.

(c) Raise and lower the car slowly. Do not try to rush the action of the hoist, as the gears may slip.

(d) Do not attempt to raise a vehicle that may be heavier Than the capacity of the hoist.

(e) Except for cleaning purposes, never raise the hoist when it is not in use.

(6) Self protection during work. When working on raised objects, stand in such a position that your feet will not be crushed if the object should fall.

5. Car pits.

The use of existing pits, elevated racks and various mechanical lifts for lubrication and other work is acceptable but not recommended except pits used for railroad equipment. Twin post adjustable hydraulic air-oil operated, flush-floor mounted lifts are recommended for this purpose and shall be specified in new construction. In the use of existing pits, the following precautions shall apply:

a. Only approved cleaning compounds shall be used in car pits. Never use gasoline or other flamable solvents.

b. Do not place tools or debris on pit steps and always keep the steps free of oil and grease.

c. Arrange for proper lighting in the pits.

d. Keep the drain open.

e. Erect adequate safeguards around pits.

f. Do not allow unauthorized personnel in pits.

g. Keep guard chains for pits in place when the pits are not in use.

6. Charging Batteries.

a. Beware of burns and shocks when charging batteries. Use rubber gloves when necessary.

b. Vent caps should be replaced before attaching or detaching charger cable; fumes arising from batteries in the recharging line are flammable.

c. Be sure that connections to batteries are properly made and secured.

d. Care shall be used in handling battery acids. When preparing electrolyte, the acid shall always be poured into the water.

e. Never "flash" or short-circuit a battery to test its strength. As stated above, the hydrogen gas is highly inflammable and a spark may cause an explosion.

7. Installing Tires.

a. Removing hub cap. When removing a hub cap, hold one hand against the side of the cap so that it does not fly into your body when it is released.

b. Remove the tire. When removing a tire from a wheel, remove the core from the valve stem and turn the wheel until the valve stem is on the lower quarter; then pull the tire opposite the stem. This saves lifting the tire, which can be rolled off the wheel onto the ground. Such a procedure is particularly useful when changing truck or bus tires.

c. Cracked rims. In replacing tires, take care that the rims are in good condition and that the lug nuts are tight.

d. Lock rings. See that the lock rings are properly installed. This should be done before the tire is fully inflated.

e. Inflating the tire. Inspect a tire for defects and determine the proper pressure before inflating. When inflating a tire, turn your face away from it; never hold it between your legs. Tires on split wheels must be deflated before removing the wheel from the vehicle and inflated after installing the wheel on the vehicle.

f. Installing tire on wheel. When putting a tire on a wheel, turn the wheel until the opening for the valve stem is on top. Then, resting the tire against the wheel with the stem on top, stoop, place a hand on each lower quarter of the tire and lift it into place.

g. Split wheels. All bolts on split or two piece wheels must be tightly secured before inflating tire. Tire must be deflated before loosening bolts.

8. Sodium Filled Valves. Automotive shop mechanics and supervisors shall be familiar with the hazards of the metallic sodium found in "sodium filled" engine valves. Special provision shall be made for the temporary storage and disposal of the parts when they are replaced. They shall not be discarded to the metal scrap pile, but shall be shipped to the nearest naval ammunition depot for proper disposal. They shall be appropriately tagged for identification.

FUELING MOTOR VEHICLES

1. Autohrized Personnel. Only authorized personnel shall be allowed to fuel motor vehicles and they shall have a thorough knowledge of the hazards involved.

2. Care of Pumps.

a. If the pump is electrically operated, be sure that the motor is shut off after the gasoline has been delivered.

b. Check at regular intervals for leaks at pipe connections, stuffing box, and meter. If leaks are found, do not attempt to repair them. Call a repairman, and keep the pumps out of service until the repairs have been made.

c. Have the base bolts secure at all times.

d. Do not attempt to make electrical repairs on pumps. Call a serviceman.

3. Using fueling equipment.

a. Equipment maintenance. Do not use leaky hose, pumps, valves or faucets. Arrange for them to be repaired at once.

b. Gasoline containers. Gasoline shall not be left standing in unlabeled containers; metal safety can must always be used. If gasoline is to be carried away, it shall be done only when in the metal safety can, tightly capped and suitable marked.

c. Automatic dispensing nozzles. Automatic shut-off dispensing nozzles may be used without attendance, only if the nozzles are approved and listed as such, iwth limitation by the Underwriter's Laboratories, Inc. When such nozzles are used without attendance, the following precautions shall be observed.

(1) The engine and lights of the vehicle being fueled shall be shut off.

(2) Exhaust extensions of operating internal combustion engines shall be at least ten feet from the point of fuel delivery.

(3) Each automatic shut-off nozzle shall be checked daily by attendants for wear or damage; shall be checked weekly by the station fire department personnel; and removed and repaired or adjusted by a manufacturer's representative at six-month intervals or after 50,000 cycles of operation, whichever comes first. Records of these inspections shall be kept by the service station.

(4) A 50 pound wheeled CO_2 or 30 pound dry chemical extinguisher shall be provided at each service station where such nozzles are used.

(5) Attendants shall be fully instructed in the regular inspection of the automatic shuf-off nozzles and the use of the fire extinguishers.

4. Fueling Procedure.

a. Bonding. To prevent electrical static discharges, tank and nozzle shall be dept in metallic contact while gasoline is being poured into the fuel tanks. This rule applied to all kinds of motor vehicles, and especially to gasoline trucks.

b. Proximity to antennas. The fueling of motor vehicles in the proximity of antennas and antenna down leads should be avoided or conducted with special precautions. An ungrounded automobile, ungrounded filling nozzle, or merely the attendant's body in close proximity to transmitting antennas and down leads, may produce sparks sufficient to ignite gasoline vapor when the nozzle comes in contact with the tank opening. Pump nozzles must be grounded at all times, and motor vehicles, when fueling, must also be grounded before opening the tank.

c. Danger from fumes. To minimize the effects of gasoline fumes, the face should be turned away from the fuel pipes while making deliveries of gasoline. Always drain the nozzle before removing it from the tank of a vehicle.

d. Battery terminals. If the gasoline tank is located under the seat, do not permit the nozzle to touch the battery terminals.

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e. Danger of overfilling. Take special care that fuel tanks are not filled to overflowing. This is particularly important in the case of motorcycles.

5. Fire During Fueling.

If fire should break out in the fuel spout during fueling, remove the hose from the tank immediately and smother the fire with CO_2, dry chemical, or foam extinguishers, dirt, sand or a wet cloth (preferably chamois, if it is available).

6. After-Fueling Procedures.

a. Caps and plugs. Replace caps or plugs securely immediately after using drums or barrels containing gasoline. Caps and plugs should be in place when drums or barrels are empty, and these containers should be removed from the garage as soon as possible.

b. Pumps. If the gasoline pump is of the visible bowl type, drain the gasoline from the bowl when securing the pumps.

c. Measuring cans. Turn empty measuring cans bottom up and dry them thoroughly before storing them.

d. Personal hygiene. After handling gasoline, mechanics should wash their hands thoroughly before eating. Clothing that has become soaked with gasoline should be changed immediately, to prevent possible burns and dermatitis of the skin. Gasoline soaked rags should never be carried in the pockets.

Gas

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Basic Principles of Electricity

1. Nature of electricity.

    a. Electricity is the flow of electrons from atom to atom.

        (1) An atom is the smallest unit of all matter consisting of equal numbers of particles called electrons and protons.

            (a) Protons have positive (+) charge potential.

            (b) Electrons have negative (-) charge potential.

    b. Utilizing the electron theory we say electrons flow from the negative to positive terminals of a circuit.

2. Electrical circuits.

    a. A basic circuit consists of:

        (1) Voltage source - such as a battery.

        (2) Resistor/load - such as a light bulb.

        (3) Conductors - wire to connect the circuit components.

    b. The 3 types of complete circuits:

        (1) Series - one path for current to follow, this circuit has high resistance.

        (2) Parallel - Two or more paths for current to follow, this circuit has low resistance.

        (3) Series/Parallel - A combination of the above two, this circuit has medium resistance.

    c. Definitions of circuit failure.

        (1) OPEN - a break or interruption in a circuit such as a switch open, a wire loose from a connection or a blown fuse.

        (2) GROUND - when any part of a wiring circuit unintentionally touches the vehicle frame - normally contact between conductors and the iron frame or vehicle body.

        (3) SHORT - occurs when conductor touches conductor such as when the insulation between two wires fail and the wires touch.

3. Electricity - how it works.

   a. Amperage

      (1) Measurement of electron (current) flow, i.e. gallons per minute.

   b. Voltage

      (1) Measurement of the pressure used to make electrons move along a conductor.

   c. Resistance

      (1) Opposition to flow of electrons (current).

         (a) Resistance is directly related to 4 items.

            1 The length of the circuit.

            2 The size of the conductor.

            3 The material the conductor is made of.

            4 The temperature of the wire.

               a Electron flow generates heat. Proper circuit conductor size will pass off the required amount of heat and allow current to flow.

   d. Definition of conductors/insulators and semi-conductors:

      (1) Conductor - A material which will easily allow current to pass through it in either direction such as copper.

      (2) Insulator - Prevents the passing of current through it.

      (3) Semi Conductor - A material which is neither a good conductor or an insulator, but has a definite use.

         (a) Diode - An electrical device that will allow current to pass through it in one direction only.

            1 May be positive or negative.

         (b) Zener Diode - Will allow current to pass through it in one direction and only allow current above a specified voltage to flow in the reverse direction.

            1 Primarily used in control circuits.

(c) Transistors - Controls the current in a circuit by either allowing or stopping it.

1 Polarity of transistors can be changed by the combining of different atomic weight materials in manufacture.

a Primarily used in transistorized regulators.

e. Magnetism

(1) A matter must have the ability of possessing a North and South Pole to be used as a magnet. (Rubber, wood, paper, glass do not possess this ability).

(a) Permanent magnets are: Matter which has had its magnetic particles alligned to give it a permanent North and South Pole.

1 Comes in many shapes but primarily bar and horseshoe and constructed of alloy steel.

(b) Electro-magnetism is: Electrons flowing thru a conductor. They will set up magnetic lines of force in a circle around the conductor. Circuit polarity has a definite relationship to the lines of force, as does the amperage flowing.

1 A simple electromagnet is constructed by placing a loop in the conductor. A usable electromagnetic is constructed by placing a soft metal bar through the center of the loop thus increasing the magnetic strength. Magnetic strength is further increased by increasing the number of turns (loops) around this bar. More turns using a smaller gauge wire will give a stronger electromagnet using lower amperage requirements on the primary side. Thus a 12V electro-magnet can do the same work as a 115V electro-magnet because of the number of turns and conductor size.

(c) Rules of magnetism:

1 Lines of force flow from north to south.

2 Magnetic lines of force never cross nor can they be insulated.

3 Like poles repel - Unlike poles attract.

f. Electro-magnetic induction

(1) If a conductor is passed thru a stationary magnetic field, current will be induced to flow in this conductor (as in a D.C. Generator).

(a) The same induction can be accomplished by having a moving magnetic field and a stationary conductor as in an A.C. Generator (Alternator).

g. Electro-magnetic repulsion

(1) By introducing current into a conductor passing thru the stationary magnetic field we utilize the rule of magnetism "Like Poles Repell". This repulsion of the like poles cause the conductor to turn away. The turning away (rotary motion) is the principle of operation of a cranking motor.

NAVAL CONSTRUCTION TRAINING CENTER
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JOB SHEET

TITLE: Gasoline Engine Disassembly, Inspection and Assembly

INTRODUCTION: The purpose of this job sheet is to guide you in the practical performance of disassembling, cleaning, inspecting, measuring and assembling a 6 cylinder gasoline engine. As a team member, you will use the required hand and special tools for disassembly and will follow specific procedures as given in this job sheet. These will cover orderly removal of accessories, valve system, cylinder head gaskets, oil pan, oil pump and strainer, connecting rods and pistons. At designated points on the job sheets, the instructor will inspect procedures to determine the job errors and the bench arrangement and protection of parts before team may proceed to next procedure. Indivdual and team performance must be in accordance with the job sheet and manufacturer's specifications, without deviation.

Clean, inspect, measure and store disassembled engine parts. This will be done in accordance with procedures established by this job sheet based on manufacturer's specifications and recommendations, without deviation.

Assemble the 6 cylinder engine parts and accessories, torqueing mounting bolts to specified tension while using the required special tools necessary for engine assembly. The student will perform as a member of a team. The procedures must be in accordance with this job sheet and manufacturer's specifications without deviation.

TOOLS, EQUIPMENT AND MATERIALS:

1. Air compressor.
2. Automotive shop hand tool kits.
3. Bench grinders.
4. Calipers.
5. Drip pans.
6. Engine stands.
7. Ford 6 cylinder gasoline engines.
8. Micrometer calipers.
9. Plastigauge.

10. Spark plug gap gauges.

11. Telescoping gauge.

12. Thickness gauges.

13. Torque wrenches.

14. Vices.

CONDITIONS:

1. Student teams of two (2) students each are assigned to a 6 cylinder gasoline engine to accomplish disassembly, inspection/measuring of parts, and assembly.

2. Each team will be provided with all required tools, manuals and a job sheet.

3. Preceding the shop performance all aspects of the job with necessary background data is covered in classroom lecture/discussion.

PROCEDURES: Place each part removed in order as illustrated in picture.

CHECK WITH INSTRUCTOR AT EACH STOP

A. Engine disassembly.

1. Turn off fuel valve. (Valve located under fuel tank.)

2. Disconnect and remove battery.

3. Remove radiator cap and drain water from the radiator and block into pail. (Dump water, clean and wipe pail dry, replace in rack.)

4. Drain lubricating oil from the crankcase into oil can. Empty oil into yellow oil drum; install oil drain plug in pan. (Clean and wipe can dry, replace can.)

5. Loosen upper and lower hose clamps, and remove both hoses and upper radiator brace.

6. Remove radiator with support brackets.

STOP: Instructor Check Point ____________________

7. Remove fuel suction line.

8. Remove fuel line between fuel pump and carburetor.

9. Remove the air cleaner, oil lever bayonet gauge, PCV valve and hose.

10. Remove vacuum line between carburetor and distributor.

11. Remove exhaust pipe at manifold and exhaust valve flange.

STOP: Instructor Check Point ______________________________

12. Disconnect all wiring and control cables from engine components.

NOTE: DO NOT REMOVE ANY WIRING OR CABLES FROM INSTRUMENT PANEL OR CRANKING MOTOR !!!!

13. Remove complete instrument panel assembly.

14. Remove the alternator drive belts and fan belt.

15. Remove the fan blade mounting assembly and alternator.

16. Remove the water pump pulley and water pump.

17. Remove the fuel pump, cranking motor, distributor cap and wires.

STOP: Instructor Check Point ______________________________

18. Remove carburetor assembly.

19. Remove ignition coil and distributor.

20. Remove the rocker arm cover and tappet cover.

21. Loosen rocker arm stub nuts.

22. Remove valve push rods; place on bench in proper sequence.

23. Remove spark plugs from cylinder head.

24. Loosen head bolts and remove cylinder head assembly.

25. Remove oil pump drive shaft and lifters. Place lifters on bench in proper sequence.

STOP: Instructor will demonstrate vibration damper removal.

26. Remove crankshaft vibration damper.

STOP: Instructor Check Point ______________________________

27. Remove oil pan, clean thoroughly before stowing.

28. Invert engine (use caution in doing this and secure the engine stand with the safety pin provided).

29. Remove timing gear cover.

30. Remove valves from cylinder head. Place in proper sequence in rack.

STOP: Instructor Check Point ____________________

31. Carefully observe the markings on the main and connecting rod bearing caps.

32. Remove oil pump.

33. Remove engine stand safety lockpin; rotate engine clockwise ninety degrees; reinstall safety lockpin.

STOP: Instructor Check Point ____________________

34. Remove piston/pistons as directed by the instructor.

35. Remove safety lock pin; rotate engine counterclockwise ninety degrees; install safety lock pin. (Crankshaft will be up.)

36. Remove main bearing cap/caps as directed by instructor.

37. Be sure that all parts are neatly stowed and cleaned as directed and illustrated. Wipe excess oil from the engine block, but leave an oil film on all machined surfaces.

STOP STOP STOP STOP STOP STOP STOP

B. Engine inspection and measurement.

NOTE: Instructor will indicate to each team the cylinder and bearing surfaces to be measured. __________ __________

NOTE: Students will refer to manufacturer's service manual for needed specifications.

1. Rotate crankshaft until connecting rod journals to be measured are at BDC.

2. Measure connecting rod journals as directed by instructor; record micrometer readings in space provided at top of following page:

MEASUREMENT OF CONNECTING ROD JOURNALS

#_____FRONT REAR_____ #_____FRONT REAR_____

1.		
2.		
3.		

1.		
2.		
3.		

STOP: Instructor Check Point ______________________________

3. Measurement of main bearing oil clearance.

   a. Wipe oil from jouranl and bearing to be measured.

   b. Cut a section of plastigage to fit the main journal lengthwise.

   c. Place plastigage on the journal slightly off center.

   d. Place correct bearing cap with insert in place on the correct main bearing journal, (arrow point forward).

   e. With main bearing cap in place install bolts and torque to 20 ft., lbs., then 40 ft., lbs. with a final torque of 60 ft., lbs.

NOTE: Do not rotate crankshaft while plastigage is on the journal.

   f. Remove bearing caps and take readings, record readings in the space provided below:

MAIN BEARING OIL CLEARANCE

MAIN BEARING NO.__________ MAIN BEARING NO.____________

________________________ ________________________

STOP: Instructor Check Point ______________________________

NOTE: Completely remove all traces of plastigage from journal and bearing surfaces.

STOP: Instructor Check Point ______________________________

   g. Lube journals, install lower bearing half and caps and tighten to specifications.

h. Check crankshaft for freeness of rotation after each main bearing is tightened. It should turn freely.

STOP: Instructor Check Point ______________________

4. Cylinder wear measurements.

a. Position engine with cylinders in a horizontal position with cam shaft side of block down.

NOTE: Clean cylinders thoroughly.

b. Using telescoping gage with outside micrometer, measure cylinder dimensions and record results in space below.

CYLINDER #____________ CYLINDER #____________

	TOP	BOTTOM
1.		
2.		
3.		

	TOP	BOTTOM
1.		
2.		
3.		

STOP: Instructor Check Point ______________________

5. Piston ring end cap measurement.

a. Remove rings from pistons as directed by the instructor.

b. Place compression ring into cylinder near bottom of ring travel.

(1) Use piston without rings to square ring with cylinder at the correct position for measuring.

c. Using thickness gauge, measure ring gap and record measurement in space provided below.

RING GAP - CYLINDER NO.____________ RING GAP - CYLINDER NO.____________

______________________ ______________________

STOP: Instructor Check Point ______________________

6. Measurement of connecting rod bearing oil clearance.

a. Clean piston, cylinder, crankpin, connecting rod bearing and cap.

b. Insert pistons in correct cylinder with numbered side toward camshaft.

c. Cut a section of plastigage to fit crankpin lengthwise.

(1) Place plastigage slightly off center of crankpin.

d. Install cap with bearing, numbered side toward camshaft.

e. Alternately torque bolts to 15 ft. lbs., then 30 ft., lbs., with a final torque of 40 ft. lbs.

NOTE: Do not rotate crankshaft with plastigage in place.

f. Remove rod cap and determine measurement - record in space provided below.

g. Remove piston assembly from cylinder after each recording.

OIL CLEARANCE - CONN. ROD NO.________	OIL CLEARANCE - CONN. ROD NO.________
________________________________	________________________________

STOP: Instructor Check Point ______________________________

NOTE: Completely remove all traces of plastigage from crankpin and bearing.

STOP: Instructor Check Point ______________________________

C. Engine Assembly.

1. Wipe piston and piston rings clean, install piston rings on pistons (make sure ring gaps are staggered).

STOP: Instructor Check Point ______________________________

2. Install ring compressor on piston and compress rings. MAKE SURE RING COMPRESSOR IS INSTALLED CORRECTLY (RIGHT SIDE UP).

3. Clean and lubricate crankpin and bearing.

4. Install piston and connecting rod assembly in cylinder, guide the connecting rod onto crankpin, make sure numbered surfaces face the camshaft.

5. Torque connecting rod nuts to 15 ft. lbs., then 30 ft. lbs., with a final torque of 40 ft. lbs.

6. Install oil pump.

7. Remove safety lock pin, rotate engine counter-clockwise ninety degrees (Crankshaft up), install safety lock pin.

STOP: Instructor Check Point ______________________________

8. Coat timing gear cover gasket lightly with grease, place gasket on engine.

9. Rotate crankshaft until crankshaft and camshaft timing marks are aligned.

10. Install aligning tool T61P-6019-B into timing gear cover seal.

11. Install timing gear cover, align and install all screws BEFORE tightening, DO NOT OVER TIGHTEN. Remove aligning tool from crankshaft.

12. Lubricate pins, lower cylinder walls and cam lobes.

STOP: Instructor Check Point ______________________________

13. Coat pan gasket lightly with grease, place on engine.

14. Install oil pan, install and align ALL screws BEFORE tightening. DO NOT OVER TIGHTEN.

15. Remove safety lock pin from engine stand and crank engine stand to position engine right side up, insert safety lock pin.

16. Install OIL PUMP DRIVE SHAFT with slotted end up.

17. Install distributor assembly, with the rotor pointing to approximately SIX O'CLOCK. Make sure distributor shaft is fully inserted.

STOP: Instructor Check Point ______________________________

18. Install crankshaft vibration damper, torque to 60 ft. lbs.

19. Clean and install valves in cylinder head. Lubricate valve stems. Make sure positive rotating spring retainer is on exhaust valve.

20. Install valve tappets in proper sequence in block after lubricating.

21. Install cylinder head gasket with ridge up.

22. Install cylinder head on engine block.

23. Tighten cylinder head bolts in proper sequence to 50 ft. lbs., then 65 ft. lbs., with final torque of 75 ft. lbs.

24. Install valve push rods in proper sequence.

25. Engage the rocker arm(s) with the push rod(s) and tighten the rocker arm stud nut(s) sufficiently to hold the push rod(s) in place.

26. Install tappet cover.

STOP: Instructor Check Point ______________________________

27. Adjust valves using the "Buddy Throw" method to position engine.

    a. Position piston of cylinder to be adjusted to TDC compression stroke.

    b. Adjust intake and exhaust valves to zero clearance, then tighten the stud nut an additional 1/2 turn.

STOP: Instructor Check Point ______________________________

28. Lightly grease rocker arm cover gasket and install with rocker arm cover. DO NOT OVER TIGHTEN.

29. Install spark plugs. Tighten ONLY to 15 ft. lbs.

30. Install carburetor assembly.

31. Lightly grease gasket and install water pump.

32. Lightly grease gasket and install fuel pump.

33. Install water pump pulley, fan-blade assembly and drive pulley.

34. Install alternator and fan drive belts.

35. Install fuel line between carburetor and fuel pump.

36. Install vacuum line between carburetor and distributor.

STOP: Instructor Check Point ______________________________

37. Install oil level bayonet gauge and PCV valve with hose.

38. Install fuel line between fuel pump and shut-off valve. DO NOT TURN FUEL ON.

39. Install radiator with brackets to engine stand.

40. Install radiator hoses and upper radiator brace.

STOP: Instructor Check Point ______________________________

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41. Install instrument panel, carefully connect all wires and control cables to their components. Install distributor cap, coil and wires.

42. Install cranking motor.

43. Install air cleaner.

44. Install exhaust pipe to valve flange first, then to exhaust manifold. Insure that engine stand is properly aligned so that no undue strain is placed on the manifold.

45. Using a clean oil can with spout, fill crankcase to proper level with oil as directed by the instructor.

46. Fill radiator with clean water, check for leaks.

47. Check fuel supply, turn on valve, check for leaks.

STOP: Instructor Check Point ______________________________

48. Install a fully charged 12 volt battery in battery box.

49. Determine proper battery polarity, connect cable from the electromagnetic switch to battery.

50. Install ground cable on battery.

NOTE: Check to see if ANY TOOLS have been left on engine and that fan blades DO NOT touch radiator or hoses.

Instructor ONLY will start the engine on the initial start! The student will closely observe oil pressure indicator, check for oil, fuel and water leaks.

IF OIL PRESSURE DOES NOT REGISTER IN A REASONABLE LENGTH OF TIME, ENGINE WILL BE SHUT OFF AND THE CAUSE DETERMINED.

ADDITIONAL EVALUATION CONSIDERATIONS

Student may operate the engine as directed by the instructor, observing ALL SAFETY PRECAUTIONS.

D. Cooperation with team mate.

1. Gives and takes directions equally well.
2. Correctly interprets instructions.
3. Communicates in a friendly manner.
4. Provides timely suggestions and assistance to team effort.

5. Performs efficiently.

E. Use of tools.

1. Accurate tool selection.

2. Safe application of tools.

3. Reading and interpretation of measuring instruments.

F. Shop safety.

1. Handling of fuels.

2. Handling of lubricants.

3. Handling of batteries.

4. Good housekeeping.

5. Observes posted safety precautions.

6. Conforms to smoking regulations.

7. No skylarking.

G. Attitude.

1. Alertness and interest in training situation at hand.

2. Displays a genuine desire to participate.

3. Motivated towards learning.

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CMA IS 1.2.4.1

Ga5

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043

CONSTRUCTION MECHANIC
CLASS "A"

COURSE NUMBER A-610-0022

I. MEASURING INSTRUMENTS

A. Micrometer Caliper

1. Nomenclature

    a. Composed of 5 major parts.

        (1) Frame

        (2) Barrel

        (3) Anvil

        (4) Spindle

        (5) Thimble

2. Method of correcting micrometer zero-setting.

    a. Use standard.

    b. Allow for correction.

        (1) Zero-setting method will vary with different makes of micrometers, usually done by Senior P.O. assigned to the machine shop.

3. Reading the settings of the micrometer caliper.

    a. Determine the inch size of micrometer frame.

    b. One numbered barrel division represents .100 of an inch.

    c. One barrel division between the numbered division represents .025 of an inch.

    d. Beveled edge of thimble's circumference is divided into 25 divisions.

        (1) Each division represents .001 of an inch.

        (2) One complete revolution of the thimble equals 1/40 of an inch or .025.

4. Measuring diameters
   - a. Steps to be taken before measuring.
     - (1) Clean surface to be measured.
     - (2) Clean faces of spindle and anvil.
     - (3) Check spindle for free turning.
     - (4) Check micrometer for accuracy.
   - b. Measure front and rear of journal for taper.
     - (1) Measure diameter at three (3) positions.

B. Calipers
- 1. Inside calipers
  - a. Checks internal measurements.
    - (1) Measurements must be read with aid of a rule.
      - (a) Instructor demonstrates
- 2. Outside calipers
- 3. Taking measurements with calipers.

C. Thread gauges
- 1. National course (U.S.S.) United States Standard
- 2. National fine (S.A.E.) Societ of Automotive Engineers
- 3. Method of checking threads with gauges (mention depth) etc .
  - a. Used to find number of threads per inch (pitch)
    - (1) Instructor demonstrate

D. Thickness Gauges (feeler gauges) and step gauges
- 1. Used to check very small clearances between two flat surfaces.

E. Spark plug gap gauges
- 1. Advantages of round gauge over flat gauge.
  - a. Flat feeler may not measure point opening if used on roughened points as accurately as a round gauge.

2. Use of spark plug gauge.

   a. To provide spark plugs with an accurate air gap between electrodes.

F. Miscellaneous Measuring Instruments

1. Rulers

   a. Common rule

      (1) Calibrated in inches and common fractional parts.

   b. Decimal rule

      (1) Calibrated by increments of tenths.

   c. Tape rule

      (1) Same as common rule, except that it is flexible, and may be rolled up.

   d. Folding rule (Carpenters rule)

      (1) Same as common rule, except that it may be folded.

2. Telescoping gauges

   a. Used to measure inside dimensions with the aid of an outside micrometer.

NOTE: When transfering reading from telescope gauge to outside micrometer don't squeeze micrometer down too tight or reading will change.

3. Inside micrometer

   a. Used to measure inside dimensions without the aid of an outside micrometer.

4. Depth micrometer

   a. Calibrated same as micrometer caliper.

      (1) Calibrations progress in reverse direction

5. Dial indicators

   a. Has a contact point that bears against a shaft or rod to check its alignment and wear.

  - b. The common dial indicator has a dial that's graduated in thousandths of an inch both plus and minus.

G. Importance of Accuracy

1. Quality and efficiency of work performed.

2. Extent of repairs needed.

H. Care of Measuring Instruments

1. These are precision tools and should receive utmost care.

   a. Protect from rust.

   b. Protect from lint.

   c. Avoid mechanical damage.

   d. Keep clean and lightly oiled, dip in kerosene let drip dry.

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PORT HUENEME, CALIFORNIA
CONSTRUCTION MECHANIC CLASS "A" COURSE NUMBER A-610-0022

FRACTIONS

FRACTIONS: A fraction is one or more of the equal parts into which anything may be divided. For example, three eighths means that the whole is divided into eight parts and three of these parts are taken. A fraction also indicates division. A fraction has two parts called terms. One is the denominator which is written below the line and this tells into how many parts the whole has been divided. The numerator or the number above the line tells how many of these parts are taken.

NOTE: $\frac{3}{8}$ - Numerator
Denominator

NOTE: By cancellation, we can reduce a fraction to its lowest terms. The numerator and denominator of a fraction may be divided or multiplied by the same number without changing the value of the fraction.

EXAMPLE: Reduce the following fractions: 4/8

$\overline{)\;4/8 = 1/2\qquad\qquad}$ 1/2 x 4/4 = 4/8

Addition of common fraction: Is the uniting of two or more fractions into one. The fraction, whole number, or mixed number obtained is called the sum

THE RULE FOR THE ADDITION OF COMMON FRACTIONS IS: Place the fractions on a column the same as in the addition of whole numbers. Reduce them all to a common denominator; add all the numerators and place their sum over the common denominator. To reduce fractions to their least common denominator, write all of the denominators in a horizontal line and divide by the number that will go into the most denominators without a remainder. Continue this process until the last line is composed entirely of ones. Then multiply all of the divisors together and their product will be the least common denominator.

EXAMPLE: Add the following fractions: 3/4, 5/6 and 7/8

EXAMPLE: Find the lease common denominator of 3/4, 5/6 and 7/8

2/4, 6, 8	1. Write the denominators one beside the other in a divisi box
2/2, 3, 4	2. Divide by a number that will gointo the greatest number denominators
3/1, 3, 2	3. Repeat this division until the quotients are all one.
2/1, 1, 2	4. Multiply all divisers to arrive at the least common denominator.

EXAMPLE: Least common denominator is 2 x 2 x 3 x 2 = 24

3/4 = 18/24
5/6 = 20/24
7/8 = 21/24
59/24 = 2-11/24 (Reduce all fractions to their lowest form).

SUBTRACTION OF COMMON FRACTIONS IS: The process of taking one common fraction from another, The fraction , whole number, or mixed number, Reduce them to a common numerator of the minuend and place their difference over the common denominator

EXAMPLE: (1) 1/2 = 2/4
- 1/4 = 1/4
1/4 Remainder or difference

(2) 3/16 = 3/16
- 1/8 = 2/16
1/16 Remainder or difference

MULTIPLICATION OF COMMON FRACTION IS: The process of multiplying one fraction by another, multiply the numerators together and place the product over the product of the denominators obtaining a new numerator and new denominator. Then if possible, reduce the new fraction formed to its simplest form

EXAMPLE: (1) Multiplicand

1/8 x 2/5 =2/40

(2) Multiplier

3/8 of 4/5 4/5 x 1/2=

12/80 = 3/20

EXPLANATION OF THE WORD "OF": The work "of" has exactly the same meaning as the multiplication sign "x". Hence, 2/3 of 4/5 is the same as 2/3 x 4/5=8/15

MULTIPLICATION OF FRACTIONS BY CANCELLATION: If a number of fraction and whole numbers or mixed numbers are to be multiplied together, the method of cancelling can be used to great advantage.

THE RULE OF CANCELLATION FOR FRACTIONS IS: Separating the numerator and the denominator of the fraction into their factors and dividing by (cancelling out) their common factors.

EXAMPLE: 14/16 x 8/9 x 3/4 = 16/16 x 8/9 x 3/4 = 7/12

DIVISION OF COMMON FRACTIONS: Is the process of dividing one fraction by another fraction. The fraction to be divided is called the dividend. The fraction which is divided into the dividend is called the divisor and the result is called the quotient.

THE RULE FOR THE DIVISION OF FRACTIONS IS: To divide one fraction by another, put down the fractions the same as in the multiplication for fractions; then invert the divisor and multiply the numerators together and the denominators and reduce to its simplest form. After inverting the divisor, cancellation should be used when ever possible. Cancellation consists of cancelling out the factors which are common in both the numerator and the denominator and then muitiply the remaining numerators together and reduce the result or product. DIVIDEND

EXAMPLE: (1) 1/8 ÷ 1/5 = 1/8 x 5/1 = 5/8 Quotient

Divisor

EXAMPLE: (2) 1/4 ÷ 3/2 = 1/4 x 2/3 = 2/12 = 1/6

Remember for division of fractions, change the division sign to the multiplication sign, invert the divisor and proceed as in multiplication

<u>CONVERSION OF COMMON FRACTIONS TO DECIMAL EQUIVALENTS</u>: A common fraction is an indicated division. By dividing the numerator by the denominator, the resulting quotient will be the decimal equivalent of the fraction.

<u>THE RULE FOR CONVERTING A COMMON FRACTION TO A DECIMAL EQUIVALENT IS</u>: Since a fraction is an indicated division, divide the numerator by the denominator, putting a decimal after the numerator and adding zeros and carry out the division to as many decimal places as are desired.

EXAMPLE: (1)

```
         .625
5-8 ) 5.000
      4 8
        20
        16
         40
         40
```

Decimals play a very important part in mathematics and solving of mathematical problems. By the use of decimals, more exact results can be obtained in the solution of problems. Various trades require different degrees of accuracy and also some trades require measurements expressed in decimal form. It is therefore necessary for the mechanic to be able to use decimals, convert decimals to common fractions.

A decimal is a fraction whose denominator is a power of 10, that is 10, 100, 1000, etc. It is written without the denominator, but the power of ten, which should represent the denominator is denoted by the number of digits on the right hand side of a dot called the decimal point.

<u>ADDITION OF DECIMALS</u>:

<u>THE RULE FOR THE ADDITION OF DECIMALS IS</u>: To add decimals, write the numbers in a column so that the decimal points are in the same column, add each column separately. Place the decimal point on the sum in the same column as the other decimal points.

```
EXAMPLE: (1) 21.05                    (2)  678.764
             22.02                          33.432
             23.10                           7.010
             66.17 Sum                     719.206 Sum
```

<u>SUBTRACTION OF DECIMALS IS</u>: The process of taking one decimal from another.

<u>THE RULE FOR THE SUBTRACTION OF DECIMALS IS</u>: To subtract decimals, write the numbers in a column so that the decimal points are in the same column. Place the decimal point in the difference in the same column as the other decimal points.

```
EXAMPLE: (1) 24.05 Minuend
             22.10 Subtrahend
              1.95 Remainder or difference
```

MULTIPLICATION OF DECIMALS: Is the process of multiplying the multiplicand by the multiplier.

THE RULE FOR THE MULTIPLICATION OF DECIMALS IS: To multiply decimals, place the last figure of the multiplier under the last figure of the multiplicand; then starting at the right multiply each figure of the multiplicand by each figure in the multiplier. Beginning at the right point off in the product as many decimal places as there are dicimal places in both the multiplier and the multiplicand. The resulting answer is the product.

EXAMPLE: (1)

$$
\begin{array}{rl}
25.25 & \text{Multiplicand}\\
\underline{1.13} & \text{Multiplier}\\
7575 & \\
2525 & \\
\underline{2525} & \\
28.5325 & \text{Product}
\end{array}
$$

DIVISION OF DECIMALS: Is the process of finding the value of one of an even number of equal parts into which a quantity is to be divided. When the quantity is divided by another, the first one is called the dividend; the second is called the divisor, and the result which is obtained is called the quotient.

THE RULE FOR THE DIVISION OF DECIMALS IS: To divide decimals, put the dividend down with the divisor to the left of it, with a curved line separating the two quantities. Proceed as in long division. The quotient is pointed off from right to left the number of places equal to the difference between the number of decimal places in the dividend and the divisor. When there are more decimal places in the divisor than in the dividend, add zeros to the dividend and carry out the division as far as required.

EXAMPLE: (1)

$$
\begin{array}{rl}
 & \underline{3\ \text{Quotient}}\\
1.5\,) & 4.5\ \text{Dividend}\\
 & \underline{4\ 5}\\
 & 0\ 0
\end{array}
$$

CONVERSION OF DECIMAL FRACTIONS TO COMMON FRACTIONS IS: The process of changing a decimal fraction to a common fraction.

THE RULE FOR CONVERSION OF DECIMAL FRACTIONS TO COMMON FRACTIONS IS: To reduce a decimal fraction to a common fraction, place the number which appears after the decimal point over 1 with the same amount of zeros as there are figures appearing in the numerator. Now reduce this common fraction to its simplest form.

EXAMPLE: (1) Convert .625 to a common fraction

$$\frac{625}{1000} = \frac{25}{40} = 5/8$$

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Port Hueneme, California 93043

CM "A" WS 1.2.4.1

Construction Mechanic Class "A" Course Number A-610-0022

MATHEMATICS WORK SHEET

DECIMALS

ADDITION:

1.	2.	3.	4.	5.
.5	.06	4.250	1.260	3.11
.2	.04	6.000	.483	24.00
.1	.03	8.755	.900	.60

SUBTRACTION:

6.	7.	8.	9.	10.
625.75	436.62	218.08	1.0000	.4980
234.	148.35	139.25	.6536	.4058

MULTIPLICATION:

11.	12.	13.	14.	15.
8.75	2.45	12.36	3.37	3.14
3.5	2.56	.45	1.12	2.5

DIVISION:

16. 32) .208

17. .063) .875

18. .625) 72

19. 6.05) .454

20. .08) 6.455

CMA WS 1.2.4.1

FRACTIONS

ADDITION:

1.	2.	3.	4.	5.
1/5	1-1/2	2-3/4	1/5	1-1/8
1/5	1-1/4	4	1/4	1-1/4
2/5	1-1/4	1-1/4	1/4	3-3/8

SUBTRACTION:

1.	2.	3.	4.	5.
4-5/6	5-1/4	7-1/5	6-3/4	5-19/32
1/6	3	3-3/8	2-5/16	2-13/32

MULTIPLICATION:

1. 4 x 1/2
2. 4/5 x 1/2
3. 3-2/9 x 8-3/4
4. 3/4 x 4/9 x 6/11 x 3-1/7
5. 2-2/5 x 7-1/2 x 3-1/3 x 2-1/10

DIVISION:

1. 2 ÷ 2-1/2
2. 21 ÷ 3/4
3. 3/8 ÷ 4-2/5
4. 2-3/4 ÷ 4-2/5

CONVERT FRACTIONS TO DECIMAL EQUIVALENTS:

1. 1/16 2. 1/4 3. 3/8 4. 7/16 5. 13/16

CONVERT DECIMALS TO FRACTION EQUIVALENTS:

1. .09375 2. .1875 3. .3750 4. .3125 5. .8750

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CONVERSION CHART

CM "A" IS 1.2.4.3
Conversion Chart

SHOWING MILLIMETER SIZES, FRACTIONAL AND DECIMAL INCH SIZES AND NUMBER DRILL SIZES

Gas

Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional
.1	.0039			1.75	.0689			....	.1570		22	6.8	.2677			10.72	.4219	27/64
.15	.0059			....	.0700		50	4.0	.1575			6.9	.2716			11.0	.4330	
.2	.0079			1.8	.0709			....	.1590		21	....	.2720		I	11.11	.4375	7/16
.25	.0098			1.85	.0728			....	.1610		20	7.0	.2756			11.5	.4528	
.3	.0118			....	.0730		49	4.1	.1614			....	.2770		J	11.51	.4531	29/64
....	.0135		80	1.9	.0748			4.2	.1654			7.1	.2795			11.91	.4687	15/32
.35	.0138			....	.0760		48	....	.1660		19	....	.2811		K	12.0	.4724	
....	.0145		79	1.95	.0767			4.25	.1673			7.14	.2812	9/32	....	12.30	.4843	31/64
.39	.0156	1/64	...	1.98	.0781	5/64	...	4.3	.1693			7.2	.2835			12.5	.4921	
.4	.0157			....	.0785		47	....	.1695		18	7.25	.2854			12.7	.5000	1/2
....	.0160		78	2.0	.0787			4.37	.1719	11/64	...	7.3	.2874			13.0	.5118	
.45	.0177			2.05	.0807			....	.1730		17	....	.2900		L	13.10	.5156	33/64
....	.0180		77	....	.0810		46	4.4	.1732			7.4	.2913			13.49	.5312	17/32
.5	.0197			....	.0820		45	....	.1770		16	....	.2950		M	13.5	.5315	
....	.0200		76	2.1	.0827			4.5	.1771			7.5	.2953			13.89	.5469	35/64
....	.0210		75	2.15	.0846			....	.1800		15	7.54	.2968	19/64	...	14.0	.5512	
.55	.0217			....	.0860		44	4.6	.1811			7.6	.2992			14.29	.5625	9/16
....	.0225		74	2.2	.0866			....	.1820		14	....	.3020		N	14.5	.5709	
.6	.0236			2.25	.0885			4.7	.1850		13	7.7	.3031			14.68	.5781	37/64
....	.0240		73	....	.0890		43	4.75	.1870			7.75	.3051			15.0	.5906	
....	.0250		72	2.3	.0905			4.76	.1875	3/16	...	7.8	.3071			15.08	.5937	19/32
.65	.0256			2.35	.0925			4.8	.1890		12	7.9	.3110			15.48	.6094	39/64
....	.0260		71	....	.0935		42	....	.1910		11	7.94	.3125	5/16	...	15.5	.6102	
....	.0280		70	2.38	.0937	3/32	...	4.9	.1929			8.0	.3150			15.88	.6250	5/8
.7	.0276			2.4	.0945			....	.1935		10	....	.3160		O	16.0	.6299	
....	.0292		69	....	.0960		41	....	.1960		9	8.1	.3189			16.27	.6406	41/64
.75	.0295			2.45	.0964			5.0	.1968			8.2	.3228			16.5	.6496	
....	.0310		68	....	.0980		40	....	.1990		8	....	.3230		P	16.67	.6562	21/32
.79	.0312	1/32	...	2.5	.0984			5.1	.2008			8.25	.3248			17.0	.6693	
.8	.0315			....	.0995		39	....	.2010		7	8.3	.3268			17.06	.6719	43/64
....	.0320		67	....	.1015		38	5.16	.2031	13/64	...	8.33	.3281	21/64	...	17.46	.6875	11/16
....	.0330		66	2.6	.1024			....	.2040		6	8.4	.3307			17.5	.6890	
.85	.0335			....	.1040		37	5.2	.2047			....	.3320		Q	17.86	.7031	45/64
....	.0350		65	2.7	.1063			....	.2055		5	8.5	.3346			18.0	.7087	
.9	.0354			....	.1065		36	5.25	.2067			8.6	.3386			18.26	.7187	23/32
....	.0360		64	2.75	.1082			5.3	.2086			....	.3390		R	18.5	.7283	
....	.0370		63	2.78	.1094	7/64	...	....	.2090		4	8.7	.3425			18.65	.7344	47/64
.95	.0374			....	.1100		35	5.4	.2126			8.73	.3437	11/32	...	19.0	.7480	
....	.0380		62	2.8	.1102			....	.2130		3	8.75	.3445			19.05	.7500	3/4
....	.0390		61	....	.1110		34	5.5	.2165			8.8	.3465			19.45	.7656	49/64
1.0	.0394			....	.1130		33	5.56	.2187	7/32	...	....	.3480		S	19.5	.7677	
....	.0400		60	2.9	.1141			5.6	.2205			8.9	.3504			19.84	.7812	25/32
....	.0410		59	....	.1160		32	....	.2210		2	9.0	.3543			20.0	.7874	
1.05	.0413			3.0	.1181			5.7	.2244			....	.3580		T	20.24	.7969	51/64
....	.0420		58	....	.120C		31	5.75	.2263			9.1	.3583			20.5	.8071	
....	.0430		57	3.1	.1220			....	.2280		1	9.13	.3594	23/64	...	20.64	.8125	13/16
1.1	.0433			3.18	.1250	1/8	...	5.8	.2283			9.2	.3622			21.0	.8268	
1.15	.0452			3.2	.1260			5.9	.2323			9.25	.3641			21.03	.8281	53/64
....	.0465		56	3.25	.1279			....	.2340		A	9.3	.3661			21.43	.8437	27/32
1.19	.0469	3/64	...	....	.1285		30	5.95	.2344	15/64	...	....	.3680		U	21.5	.8465	
1.2	.0472			3.3	.1299			6.0	.2362			9.4	.3701			21.83	.8594	55/64
1.25	.0492			3.4	1338			....	.2380		B	9.5	.3740			22.0	.8661	
1.3	.0512			....	.1360		29	6.1	.2401			9.53	.3750	3/8	...	22.23	.8750	7/8
....	.0520		55	3.5	.1378			....	.2420		C	....	.3770		V	22.5	.8858	
1.35	.0531			....	.1405		28	6.2	.2441			9.6	.3780			22.62	.8906	57/64
....	.0550		54	3.57	.1406	9/64	...	6.25	.2460		D	9.7	.3819			23.0	.9055	
1.4	.0551			3.6	.1417			6.3	.2480			9.75	.3838			23.02	.9062	29/32
1.45	.0570			....	.1440		27	6.35	.2500	1/4	E	9.8	.3858			23.42	.9219	59/64
1.5	.0591			3.7	.1457			6.4	.2520			....	.3860		W	23.5	.9252	
....	.0595		53	....	.1470		26	6.5	.2559			9.9	3898			23.81	.9375	15/16
1.55	.0610			3.75	.1476			....	.2570		F	9.92	.3906	25/64	...	24.0	.9449	
1.59	.0625	1/16	...	....	.1495		25	6.6	.2598			10.0	.3937			24.21	.9531	61/64
1.6	.0629			3.8	.1496			....	.2610		G	....	.3970		X	24.5	.9646	
....	.0635		52	....	.1520		24	6.7	.2638			....	.4040		Y	24.61	.9687	31/32
1.65	.0649			3.9	.1535			6.75	.2657	17/64	...	10.32	.4062	13/32	...	25.0	9843	
1.7	.0669			....	.1540		23	6.75	.2657			....	.4130		Z	25.03	.9844	63/64
....	.0670		51	3.97	.1562	5/32	...	....	.2660		H	10.5	.4134			25.4	1.0000	1

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CM "A" JS 1.2.6.1

Gas

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

JOB SHEET

TITLE: GASOLINE ENGINE DIAGNOSIS AND ADJUSTMENT

INTRODUCTION: You will perform specific engine tests, tune-up and engine trouble diagnosis. You will use the compression gauge, vacuum gauge, tachometer and timing light to make routine tests of engine performance. You will record the results of the tests from which you will recommend what measures are to be taken to correct any malfunctions discovered. To arrive at this you will use job sheets, manufacturer's specifications and a trouble-shooting chart. You must be correct in your tests, diagnosis and tune-up.

TOOLS AND EQUIPMENT:

1. Automotive shop hand tools.
2. Battery starter tester (BST).
3. Compression tester.
4. Hydrometer.
5. Solder gun.
6. Ford 6 cylinder gasoline engines.
7. Tach-dwell meter.
8. Timing light.
9. Vacuum gauge.

CONDITIONS:

A. Student teams of two (2) students each are assigned to a Ford 6 cylinder gasoline engine to accomplish basic diagnostic procedures and adjustments.

B. Each team is provided with all required tools, instruments and job sheet with manufacturer's manual covering the diagnosis and adjustment processes to be performed.

C. All background theory and necessary details are covered in the classroom lecture/discussion prior to the shop performance.

PROCEDURE:

A. Compression test.

1. Prestart check and bring engine to operating temperature.

2. Turn off fuel valve at fuel tank.

3. Remove all spark plugs.

4. Compression test (dry).

   a. Procedure.

      (1) Block throttle to wide-open position.

      (2) Open choke to fully-open position.

      (3) Ground coil secondary wire.

      (4) Connect tester to cylinder.

      (5) Turn engine using cranking motor.

         (a) Turn engine an equal number of times for each cylinder tested.

      (6) Gauge dial will register compression.

      (7) Check all cylinders.

      (8) Record all readings in space provided.

5. Compression test (wet).

   a. Procedure, oil-check method.

      (1) Add an equal amount of oil to each cylinder (1/2 ounce).

      (2) Recheck all cylinders.

      (3) Record all readings in space provided.

      (4) Compare readings (dry to wet), record variations.

DRY	WET	VARIATION	PROBABLE CAUSE
1. ________	1. ________	1. ________	1. ________
2. ________	2. ________	2. ________	2. ________
3. ________	3. ________	3. ________	3. ________
4. ________	4. ________	4. ________	4. ________
5. ________	5. ________	5. ________	5. ________
6. ________	6. ________	6. ________	6. ________

6. Disconnect ground cable battery.

7. Evaluation of test results.

    a. Variation between highest and lowest pressures should not exceed 15 PSI.

    b. Low reading with oil check indicates bad valves.

    c. If oil check raises reading considerably; indicates piston rings.

    d. Low reading on two adjacent cylinders may indicate blown head gasket.

STOP: INSTRUCTOR CHECK POINT ____________________

B. Spark plug service.

1. Inspect spark plugs.

    a. Broken insulation.

    b. Loose terminal.

    c. Evidence of leaking.

    d. Evidence of fouling.

    e. Burned electrodes.

2. Adjustment of plug gap using wire gauge.

    a. Plug gap .035".

        (1) Gauge should pass through plug gap with slight drag. Do not install spark plugs.

STOP: INSTRUCTOR CHECK POINT ____________________

C. Distributor service.

1. Remove distributor from engine.

2. Place in vise as directed (do not over tighten).

3. Inspect distributor assembly.

4. Remove contact points and condenser.

5. Inspect for burned, pitted or misaligned points.

6. Inspect condenser for physical damage.

7. Inspect vacuum advance unit, linkage and breaker plate for proper operation.

8. Inspect drive gear for physical damage.

9. Remove wires from cap and inspect.

10. Inspect and clean rotor and distributor cap. (Use special wire brush for terminal inserts.)

11. Clean and lubricate distributor as directed.

12. Install contact points on breaker plate.

13. Adjust points to .025".

    NOTE: Align points by bending stationary point support only. Instructor will check point adjustment after unit has been put back into operation on the engine. He will use a dwell meter. Reading must be between 37 and 42 degrees.

14. Install condenser and primary wire.

15. Do not install distributor on engine.

STOP: INSTRUCTOR CHECK POINT ______________________

D. Valve adjustments.

NOTE: Use "Buddy-throw method" of positioning engine for valve adjustment.

1. Back off valve adjustment nuts two (2) turns.

2. Adjust intake and exhaust valves to "zero" clearance. Then tighten the stud nut an additional 1/2 turn.

NOTE: Position engine as follows - "Buddy-throw method" for adjusting valves. (Adjust in firing order sequence.)

Adjust valves on cylinder number:	When intake valve starts to open on cylinder number:
1	6
5	2
3	4
6	1
2	5
4	3

NOTE: Do not install valve cover on engine.

STOP: INSTRUCTOR CHECK POINT ____________________

E. Distributor installation.

1. Position engine so that number one cylinder is TDC of compression stroke.
2. Install distributor assembly with rotor pointing to approximately six O'clock. Make sure that shaft is fully inserted. Do not tighten lock bolt.

STOP: INSTRUCTOR CHECK POINT ____________________

3. Install valve cover with gasket.
4. Install spark plugs.
    a. Torque to 15 ft. lbs. only.
5. Install distributor cap and wires.
6. Connect battery ground cable to battery.
7. Start and run engine for two (2) minutes to clear cylinders of oil.

F. Ignition timing.

1. Connect timing light to battery ignition system as directed by instructor.
2. Start engine.

3. Time ignition to occur at 6 degrees BTDC of number one cylinder.

NOTE: Disconnect and block off vacuum line from carburetor during timing operation.

STOP: INSTRUCTOR CHECK POINT ______________________

4. Connect vacuum line.

5. Remove timing light from unit.

G. Carburetor adjustment.

1. Connect tachometer to primary circuit between coil and distributor.

2. Set tachometer controls for proper number of cam lobes, voltages and RPM.

3. Operate engine until it is warmed sufficiently.

4. Adjust engine speed to 550 RPM.

    a. Adjust engine idle RPM to approximately 500 RPM.

    b. Adjust idle mixture screw until tachometer shows highest reading.

        (1) If this reading is not 550, readjust until 550 is achieved.

NOTE: The idle mixture screw is always the last screw to be adjusted.

STOP: INSTRUCTOR CHECK POINT ______________________

H. Vacuum tests.

1. Connect vacuum gauge and fitting to intake manifold.

    a. Remove pipe plug from manifold below carburetor.

        (1) Install vacuum gauge fitting.

2. Operate engine until warm.

3. Vacuum tests (engine running at idle speed).

NOTE: Check appropriate box.

a. Steady and fairly high (18 to 21 inches) yes ( ) no ( ).

(1) Normal engine.

b. Steady and low yes ( ) no ( ).

(1) Late ignition timing.

(2) Leakage around pistons and/or rings.

c. Very low yes ( ) no ( ).

(1) Leaky intake manifold gasket.

(2) Leakage around valve stems.

d. Oscillations of needle increasing with engine speed yes ( ) no ( ).

(1) Weak valve springs.

e. Gradual falling back toward zero, with engine idling yes ( ) no ( ).

(1) Restriction in exhaust system.

f. Regular dropping back yes ( ) no ( ).

(1) Restriction in exhaust system.

(2) Plug not firing.

g. Irregular dropping back yes ( ) no ( ).

(1) Sticking valves.

h. Floating motion or slow oscillation yes ( ) no ( ).

(1) Rich fuel mixture.

(2) Late valve timing.

4. Vacuum tests at variable speeds.

a. Accelerate engine and quickly close throttle while reading vacuum gauge.

(1) If needle swings momentarily to 23 - 25 inches yes ( ) no ( ).

(a) Compression is normal.

(2) If needle swings momentarily to a reading below 23 - 25 inches yes ( ) no ( ).

(a) Trouble with rings, pistons, cylinders or valves.

I. Cooperation with team mate.

1. Gives and takes directions equally well.
2. Correctly interprets instructions.
3. Communicates in a friendly manner.
4. Provides timely suggestions and assistance to team effort.
5. Performs efficiently.

J. Use of tools.

1. Accurate tool selection.
2. Safe application of tools.
3. Reading and interpretation of special tools and measuring instruments.

K. Shop safety.

1. Handling of fuels.
2. Handling of lubricants.
3. Handling of batteries.
4. Good housekeeping.
5. Observes posted safety regulations.
6. Conforms to smoking regulations.
7. No skylarking.

L. Attitude.

1. Alertness and interest in training situation at hand.
2. Displays a genuine desire to participate.
3. Motivated toward learning.

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CONSTRUCTION MECHANIC SCHOOL

CLASS "A"

INSTRUCTOR GUIDES

8-5

PHASE 2

Diesel Engine Operation and Maintenance

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Caterpillar Diesel Engine Operation

Average Time: 5 Periods (Class), 2 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Mechanic 3 & 2, NAVPERS 10644-F, pages 169-202.

2. Operation and Maintenance Instructions, Caterpillar D-333 and D-3306 Industrial Engines Form FE045040-02, Caterpillar Tractor Co., Peoria, Illinois 61602, pages 21-25.

3. Operation and Maintenance Instruction, Caterpillar D-342 Engine, Form FE31603-9, Caterpillar Tractor Co., Peoria, Illinois 61602, pages 21-34.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

   a. Diesel engine handtools.

   b. Diesel engine shop tools.

2. Equipment.

Terminal Objective: Upon completion of this unit each student will be able to operate and service Caterpillar diesel engines, models D-342 and D-3306. He will use appropriate handtools, special tools and shop equipment. His performance will conform to manufacturer's recommendations as outlined in the Job Sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines" without error.

Enabling Objectives: Upon completion of this topic each student will be able to prestart check, start, run and secure Caterpillar diesel engines, models D-342 and D-3306, while monitoring instruments and interpreting readings. All performances will conform to manufacturer's recommendations as stated in the Job Sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines" without error.

Criterion Test: Prestart check, start, run and secure Caterpillar diesel engines while monitoring instruments and interpreting readings. All performance to conform to manufacturer's recommendations as stated in job sheet.

Homework: Read:

1. Construction Mechanic 3 & 2, NAVPERS 10644-F, pages 169-202.

2. Diesel, The Modern Power, 4th edition (entire booklet).

a. Major.

(1) Caterpillar D342 Diesel Engines (3 each).

(2) Caterpillar D3306 Diesel Engines (4 each).

3. Materials (consumables).

a. Cleaning solvent.

b. Diesel fuel.

c. Diesel engine oil.

d. Wiping rags.

D. Training Aids and Devices:

1. Films.

a. MC9172A2, "A Matter of Time" (color, 23 min.).

b. MC10517, "ABC of Diesel Engines" (Color, 20 min.).

2. Locally Prepared Material.

a. Information sheet.

(1) CM "A" IS 2.1.1.1, "Magnetos".

b. Job sheet.

(1) CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines".

3. Devices:

   a. Cutaway of D-315 Caterpillar Diesel Engine.

E. Training Aids Equipment:

1. 16mm sound movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Caterpillar Diesel Engine Operation.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives (refer to page 1 of this I.G.).	
1. In this period we will discuss the history, theory and principles of operation of the average diesel engine. All particular features of a specific engine will be covered in detail when the engine is being discussed.		

OUTLINE OF INSTRUCTION

2. You will acquire a basic knowledge of diesel engines during this phase of Mechanics School, which will give you necessary information for advancement in rate, and/or future employment.

3. We will expose you to a quantity of information that may assist you in deciding upon a future occupation, and/or instill a desire to continue your education.

4. The diesel engine is here to stay, and within your life you will likely see this type engine replace many gasoline engines in the passenger cars of the future.

5. In the movie to be shown, you will see the principles of diesel in operation from the first form of its crudest stage to some of the present day engines. Any questions that may arise concerning the film will be discussed.

6. From time to time we will give facts governing the diesel engine and will produce some comparisons to gasoline engines. Each of the engines is best designed for the job it may be called upon to do.

7. Any additional paper and time for taking notes will be allowed. When a question arises, which is not clear to you, get the instructor's attention and he will make an attempt to explain in detail. If necessary time is not sufficient during the class, we will

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

I.D.1. Take notes and follow discussion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
ask you to contact us during the break, rather than holding up the class.		
8. We will show the film and have a discussion period immediately following.		
9. Suggestions for the instructor.		
a. For many Class "A" students, this will be their first encounter with diesel engines. Some good motivating factor at this time will do much to keep them alert and interested throughout the "Diesel Engine Phase" of training. Emphasize the importance of the modern diesel to the Navy, point out that the recent developments in the diesel engine such as reduction in weight, increase power and speed have placed the diesel in competition with the gasoline engine in many applications never before considered.		
II. Presentation.		
A. History.	II.A. Introduce and show movie, MC10417, "The ABC of the Diesel Engine".	II.A. Watch movie and take notes.
1. The principle of compression ignition was discovered by an indian many years ago.	II.A. Review high points of movie.	II.A. Participate in discussion.
a. Used a fire stick and piece of bamboo		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

2. Dr. Rudolph Diesel in 1892 applied same principle to an engine, using coal dust.

3. In 1897, Dr. Rudolph Diesel successfully ran a fuel oil powered engine.

B. Principles of operation of diesel engine.

II.B. Illustrate compression ratio on chalkboard.

1. A volume of air is compressed with a ratio of 16 to 1.

2. Compression pressure 400 to 600 PSI.

3. Compression temperature 800 to 1200 degrees F.

   a. Two degrees of temperature for each pound of compression.

4. Intake stroke.

   a. Only air is drawn or forced into the cylinder.

   b. Turbulence is the whirling motion of air within the cylinder.

5. Speed of engine controlled by fuel-injection period.

   a. Gasoline engine speed controlled by admission of air.

6. Diesel engine 32 to 38 percent efficient.

   a. Gasoline engine 22 to 28 percent efficient.

OUTLINE OF INSTRUCTION

b. Efficiency - useful power from heat generated.

7. Combustion pressure 60% greater than compression pressure.

   a. Rise of pressure due to burning of fuel.

   b. Combustion pressures approximately 640 to 960 PSI.

8. Combustion temperature from 2500 to 3500 degrees F.

   a. Diesel fuel burns with a constant pressure.

   b. Gasoline mixture burns with constant volume.

9. Four-stroke cycle.

   a. Intake stroke.

      (1) Full charge of air at all speeds.

   b. Compression stroke.

      (1) 16:1 (average).

   c. Power stroke.

      (1) Downward movement until exhaust valve opens.

INSTRUCTOR ACTIVITY

II.B.8. Use chalkboard to explain constant pressure/vs. constant volume.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

d. Exhaust stroke.

(1) Pumping actions of piston in 4-stroke cycle.

10. Two-stroke cycle.

a. Every downward stroke of piston is a power stroke.

b. Every upward stroke of piston is compression stroke.

11. Scavenging methods.

a. Valve-type scavenging on all 4-stroke cycle engines.

(1) Exhaust valves located in head.

(2) Exhaust valves actuated by cam shaft.

b. Uniflow-type scavenging.

(1) Air pressure developed by blower.

(2) Intake ports and exhaust valves.

(3) Air enters one end and leaves at other end of cylinder.

12. Supercharging and turbo-charging.

a. Purpose.

(1) Additional air.

(2) Additional air in cylinder permits burning more fuel to produce more power.

b. Method of accomplishing:

(1) Supercharged with blower.

(a) Gear-driven (slows down as engine lugs down).

(2) Turbo-charged with a turbine.

(a) Exhaust gas-driven (speeds up as engine lugs down).

13. Governors: (Speed-control device.)

a. Types.

(1) Constant speed.

(a) Conveyor belt power (from no load to full load, constant power).

(2) Maximum speed.

(a) Highway equipment, (limits maximum RPM engine).

(3) Variable speed.

(a) Dozer application (allows operator to maintain any desired speed).

II.B.13.a.(3) Briefly mention full-force feed. Each engine has detailed coverage.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
14. Types of lubrication and cooling systems.		
a. Automotive and tractor-type diesel engines.	II.B.14.a. Use chalkboard to explain closed pressurized, closed non-pressurized, use open cooling system for comparison.	
(1) Type of lubricating system.		
(a) Full-force feed.		
(2) Type of cooling system.		
(a) Closed, pressurized.		
(b) Closed, non-pressurized.		
C. Fuel-injection system:	II.C. Give brief discussion on various fuel systems to be studied.	II.C. Students ask questions, take notes as needed.
1. Type.		
a. Mechanical, or solid.		
(1) Pump and nozzle (Cat).		
(2) Unit injector (GMC).		
(3) Distributor (IHC - LD/LDS).		
(4) Pressure -timed (Cummins).		
2. Function of fuel-injection system.	II.C.2. Place on chalkboard. Have students write, M - Meter, I - Inject, T - Time, A - Atomize, C - Create High Fuel Pressure.	II.C.2. Students copy, M, I, T, A, C from chalkboard.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

a. Meter or measure the fuel.

b. Injection of fuel.

c. Time the injection of fuel.

d. Atomization of the fuel.

e. Create high pressure of the fuel.

MITAC

3. Fuel transfer pumps.

   a. Vane-type.

   b. Gear-type.

II.C.3. Show by chalkboard both gear and vane pumps.

II.C.3. Draw both pumps in notes.

D. Advantages and disadvantages of diesel engine.

1. Advantages of diesel engines.

   a. Reduction of fire hazard (flashpoint of diesel fuel higher than gasoline).

      (1) Fuel does not evaporate rapidly.

      (2) Elimination of fuel storage hazards.

   b. High fuel economy.

      (1) More useful power per pound of fuel.

      (2) Will burn less fuel per hour than gas engine of same horsepower.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Greater use of heat generated.		
d. Elimination of ignition system.		
(1) Ignition due to compression temperature.		
e. Less maintenance and more reliable.		
(1) More rugged parts due to high temperatures and pressures not requiring repairs.		
2. Disadvantages of diesel engines.		
a. Excess weight per horsepower.		
(1) Required for parts to withstand temperatures and pressures.		
b. Initial cost much higher than comparable gasoline engine.		
(1) More expensive parts to withstand temperatures and pressures.		
E. Caterpillar diesel engine operation.	II.E. Introduce and show film, MC9172A2, "A Matter of Time".	II.E. View film and take notes.
1. Caterpillar diesel engine description.	II.E. Review high points of film.	II.E. Participate in discussion.
a. Four-stroke cycle principle.		
(1) Oil burning.		
(2) Compression ignition.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Compression ratio of 16 to 1 (average).		
b. Cylinder block arrangement.	II.E.1.b. Use cutaway of D-315 Caterpillar engine to show and emphasize diesel engine construction.	
(1) In-line block.		
(a) 6-cylinder.		
c. Engine classification, bore and stroke.		
(1) D-342 - 5 3/4" x 8".		
(2) D-3306 - 4 3/4" x 6".		
2. Starting, operating and securing controls.	II.E.2. Take class to shop and point out controls for starting, running and securing the Caterpillar Diesel Engine.	II.E.2. Participate in discussion and take notes.
a. Compression release.		
(1) Located in various positions on different engines.		
(2) A mechanical device used to hold valves off their seats for starting purposes.		
(3) 5 3/4" bore 6-cylinder engine opens intake valves.		
(4) 5 3/4" bore engine, valves opened by pushrod action on rocker arm.		
(5) Two positions of lever for 5 3/4" bore engines.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

- (a) Start - all intake valves held open.
- (b) Run - no valves held down.

b. Starting engine.

- (1) 4-stroke cycle gasoline.
- (2) Magneto ignition.
- (3) Block arrangement starting engine.
  - (a) 2-cylinder in-line engine.
  - (b) 2-cylinder horizontal opposed cylinder.
- (4) D-3306 has direct electric starting.

II.E.2.b. Point out features of starting engine and issue information sheet CM "A" IS 2.1.1.1, "Magneto".

c. Starting engine clutch.

- (1) Wet type.
- (2) Cam over center engaged.
- (3) Clutch brake.
  - (a) Cone type.
  - (b) Used to stop pinion from turning when engaging pinion gear.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Located on rear of clutch collar and clutch housing.		
d. Starting engine transmission.	II.E.2.d. Using cutaway starting engine assembly, point out internal features.	
(1) Located behind clutch.		
(2) Two-speed selection.		
(a) High range - normal starting.		
(b) Low range - cold weather starting.		
e. Starting engine pinion.		
(1) Located on transmission output shaft.		
(2) Connects starting engine to diesel engine flywheel.		
(3) Pinion manually engaged.		
(4) Automatically disengaged by centrifugal force when diesel engine starts.		
3. Pre-start check, starting, operating and securing.	II.E.3. Have class refer to operation and maintenance instructions.	II.E.3. Refer to pages of text as directed by instructor.
a. Pre-start check.		
(1) Check lubricating oil level (add if necessary).		
(a) Starting engine.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(b) Diesel engine. (c) Starting engine transmission.	II.E.3.a. Issue Job Sheet CM "A" JS 2.1.1.1, and demonstrate operation of Caterpillar diesel engines.	II.E.3.a. Observe demonstration and follow job sheet CM "A" JS 2.1.1.1.
(2) Check water level.	a. Prestart checks.	
(3) Check fuel level.	b. Starting and operating.	
(a) Gasoline.	c. Securing.	
(b) Diesel fuel.		
(4) Position diesel throttle - make sure diesel throttle is in "NO FUEL" position.		
(5) Position compression release lever - place lever in "START" position.		
(6) Position starting engine clutch - disengaged.		
(7) Position starting engine transmission.		
(a) "High range" in warm weather (40° and above).		
(b) "Low range" in cold weather (below 40°).		
(8) Make sure all movable parts are free from obstructions.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

b. Starting and operating the starting engine.

(1) Open fuel valve on gasoline tank.

(2) Turn magneto switch to "ON" position.

(3) Latch starting engine throttle in the "IDLING" position.

(4) Crank starting engine.

(a) Pull up on handle, using top arc of travel ONLY.

(b) DO NOT spin the crank.

(c) DO NOT wrap thumb around handle.

NOTE: When the engine starts, keep the speed low until the crankcase lubricating oil has a chance to warm up and better lubricate the engine. Time will vary according to climatic conditions.

NOTE: Temperature will vary the length of time it is necessary to have the choke on. Actual experience in starting will determine the interval. Push in the choke control rod as soon as the engine will run with choke off.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Engaging starting engine pinion with diesel engine flywheel.	II.E.3.c. Direct student practice in operating Caterpillar diesel engines.	II.E.3.c. Practice operation of Caterpillar diesel engines.
(1) Apply clutch brake.		
(a) Pull clutch lever to full-disengaged position, this keeps pinion gear from turning so that it may be engaged with the flywheel of diesel engine without clashing teeth on the gears.		
d. Engaging the starting engine clutch.		
(1) Release idling latch on starting engine throttle.		
(2) Engage starting engine clutch - engage slowly until diesel engine starts to turn (watch fan blades) then snap into full engagement. Pinion will be engaged by the clutch lever.		
(3) Lubricating oil pressure and fuel pressure. With diesel engine turning over, observe lubricating oil pressure and fuel pressure. In warm weather diesel engine may be started as soon as fuel and lubricating oil pressure is in "Operating Range".		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

NOTE: On turbo-charged engines, allow the starting engine to turn the diesel at least 3 minutes before starting the diesel.

e. Starting the diesel engine.

(1) Position compression lever.

(a) Move lever directly from "start" to "run" in warm weather.

(2) Position throttle: Smartly move throttle to approximately one-half position.

(3) When diesel engine starts, it will automatically disengage starting engine pinion from diesel engine flywheel.

f. Securing starting engine.

(1) Close gasoline valve at tank and allow starting engine to run until all fuel in carburetor is used.

(2) Turn magneto switch to "OFF" position.

g. Operating the diesel engine.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Allow the diesel engine to idle for five minutes with the throttle at half position to allow engine time to warm up.		
(a) Operate the diesel engine at a moderate speed, never suddenly accelerate or decelerate.		
h. Securing the diesel engine.		
(1) Check diesel engine oil level (add if necessary).		
(2) Move throttle lever to low idle position - let run for five minutes.		
(a) To allow turbo-charge to cool and slow down.		
(3) Move throttle lever to "OFF" position.		
III. Application.		
A. Prestart check, start, run and secure Caterpillar diesel engines while monitoring instruments and interpreting readings. All performance to conform to manufacturer's recommendations as stated in job sheet without error.	III.A. Direct, supervise and evaluate student performance in conducting prestart checks, starting, running and securing a Caterpillar diesel engine while monitoring and interpreting instruments. All performance to conform to manufacturer's recommendations as stated in Job Sheet CM "A" JS 2.1.1.1, Maintenance of Caterpillar Diesel Engines".	III.A. Operate Caterpillar diesel engines conforming to manufacturer's recommendations as specified in the Job Sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines".

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
IV. Summary.		
A. History.		
B. Principles of operation of diesel engines.		
C. Fuel injection system.		
D. Advantages and disadvantages of diesel engine compared to gasoline engine.		
E. Caterpillar diesel engine operation.		
V. Test: None.		
VI. Assignment:		
A. "Operation and Maintenance Instructions" , Caterpillar D-342 Engines, Form FE 31603-9, (review entire booklet).	VI.A. Write assignment on chalkboard.	VI.A. Copy assignment.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Caterpillar Diesel Engine Maintenance

Average Time: 11 Periods (Class), 13 Periods (Pract)

Instructional Materials:

A. Texts:

1. Operation and Maintenance Instructions, Caterpillar D-333 and D-3306 Industrial Engines, Form FE045040-02, Caterpillar Tractor Co., Peoria, Illinois (entire booklet).

2. Operation and Maintenance Instructions, Caterpillar D-342 Engine, Form FE31603-9, Caterpillar Tractor Co., Peoria, Illinois (entire booklet).

3. Get a Clear Picture of Your Turbocharger and Form FE035934, Caterpillar Tractor Co., Peoria, Illinois 61602.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

   a. Diesel engine handtools.

   b. Caterpillar special tools.

Terminal Objective: Upon completion of this unit each student will be able to operate and service Caterpillar diesel engines, models D-342 and D-3306. He will use appropriate handtools, special tools, and shop equipment. His performance will conform to manufacturer's recommendations as outlined in the Job Sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines" without error.

Enabling Objectives: Upon completion of this topic each student will be able to service Caterpillar diesel engines models D-342 and D-3306 using appropriate handtools, special tools, and shop equipment. Specifically he will service cranking systems, fuel systems, and adjustment of engine valve systems. All tasks will meet manufacturer's specifications as specified in job sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines" without deviation.

Criterion Test: Service Caterpillar diesel engines using appropriate handtools, special tools, and shop equipment. Service the cranking system, fuel system and adjust engine valves. All performance is to meet manufacturer's specifications as specified in job sheet without error.

Homework: Read:

1. Operation and Maintenance Instructions, Caterpillar D-333 and D-3306 Industrial Engines, Pages 21-58.

c. Diesel engine shop equipment.

2. Equipment:

a. Major.

(1) Caterpillar D-3306 Diesel Engines (4 each).

(2) Caterpillar D-342 engines (3 each).

3. Materials (consumable).

a. Cleaning solvent.

b. Diesel fuel.

c. Diesel engine oil.

d. Wiping rags.

e. Caterpillar oil filters.

f. Caterpillar fuel filters.

g. Caterpillar air filters.

D. Training Aids and Devices:

4. Film slides:

a. Slide series: Caterpillar Diesel Engines.

5. Locally Prepared Material:

a. Job Sheet.

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(1) CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines".

3. Devices:

a. Cutaway of D-315 Caterpillar Diesel Engine.

b. Cutaway of Caterpillar Turbocharger.

E. Training Aids Equipment:

1. 35mm slide projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Caterpillar Diesel Engine Maintenance.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better mechanic.		
D. Overview:	I.D. State learning objectives.	
1. The fuel injection system is the heart of the diesel engine; therefore, it is important that you understand its function and operation. In this lesson you will learn the basic Caterpillar fuel injection system, its basic parts, their function and operation, and the flow of fuel through the system.		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Questions from this lesson will appear in the end-of-unit examination.		
3. A knowledge of fuel systems will be valuable to you in the Navy, and as a civilian mechanic.		
4. You will apply what you learn in the classroom, in the field as a construction mechanic, and as a civilian mechanic.		
5. Suggestions for the instructor:	I.D.5. Use charts and transparencies to explain fuel system.	I.D.5. Take notes as needed and/or as directed.
a. This will be the first actual contact with diesel fuel injection systems for many Class "A" students therefore each student should be given every opportunity to see and handle parts of the fuel system.		
b. Point out to the class the function that the parts play in getting the fuel to the engine cylinder at the right time, in the proper quantity and in the correct condition.		
II. Presentation.		
A. Type of fuel system.		
1. Solid or mechanical.		
a. Pump and nozzle.		
B. Flow of fuel and purpose of units.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
1. Tank.		
a. Holds supply of fuel.		
2. Primary filter (strainer).		
a. Removes large foreign particles.		
b. Washable metallic element or cartridge.		
3. Fuel transfer pump.		
a. Supplies volume of fuel to fuel manifold.		
b. Driven by a gear which is an integral part of the accessory drive shaft.		
4. Filters and filter housing.	II.B.4. Show filters to class.	
a. Removes small foreign particles.	a. Paper.	
5. Fuel pressure gauge.	b. Cotton.	
a. Alerts operator to possible fuel system troubles.		
6. Injection pump housing and manifold.		
a. Housing holds injection pumps and operating mechanisms.		
b. Manifold supplies fuel to injection pumps.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
7. Injection pumps.		
a. Times fuel delivery.		
b. Meters fuel delivery.		
c. Creates pressure required for fuel delivery.		
8. High pressure lines.	II.B.8. Pass out T/A.	II.B.8. Handle parts.
a. Carry fuel to injection valve.	a. High pressure line.	
9. Fuel injection valve.	b. Fuel injection valve.	
a. Injects fuel.	c. Precombustion chamber.	
b. Atomizes fuel.		
10. Precombustion chanber.		
a. Conditions fuel and starts it to burn.		
C. Parts and functions.	II.C. Use actual engines to show fuel flow-through system.	
1. Fuel tank.		
a. Strainer in filler hole (clean when necessary).		
b. Suction line 1 1/2" from bottom of tank.		
c. Tank fitted with a drain cock (check weekly).		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

d. Outlet line may be fitted with primary filter.

2. Fuel transfer pump.

   a. Positive displacement gear type.

   b. Supplies a volume of fuel to pump housing.

3. By-pass valve.

   a. By-pass valve opens at 15 to 20 PSI.

      (1) Located at pump on tractors.

      (2) Located at filter chamber on stationary applications.

4. Filter housing.

   a. Houses resin impregnated cellulose materials- type filter element.

   b. Removes small foreign particles.

5. Fuel pressure gauge.

   a. Three color range.

      (1) Red - danger, do not operate.

      (2) White - warning - pressure drop usually due to partially clogged filters.

      (3) Green - normal operating range.

b. Registers fuel pressure in manifold.

6. Fuel injection pump housing parts.

   a. Fuel pump camshaft.

   b. Lifter assembly.

   c. Rack assembly.

   d. Fuel manifold.

7. Fuel injection pump parts.

   a. Pump body.

      (1) Bolted to housing.

      (2) Houses barrel, plunger and delivery valve.

      (3) Contains low pressure fuel passage.

         (a) Bleed screw.

   b. Barrel.

      (1) Contains inlet port.

         (a) Aligned with low pressure.

      (2) Mated to plunger.

   c. Plunger.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) Gear segment secured to one end of plunger.

(2) Recess area is milled into one end of plunger near the opposite end to the gear segment, upper lip of recess forms a helix or spiral groove.

(3) Milled slot is a passage in the plunger that joins the top of the plunger to the cutaway area.

d. Check valve.

(1) Located above barrel.

(2) Prevents draining of high-pressure lines.

8. Fuel injection pump functions.

a. Meter.

b. Time.

c. Create high fuel pressure.

9. Injection pump operation.

a. Plunger retracted (down).

(1) Fuel enters chamber.

b. Plunger starts upward.

(1) Acceleration phase.

c. Port covered by top of plunger.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(1) Injection begins (determines timing).

(2) Pumping phase.

(a) Creates high pressure.

(3) Constant beginning of injection.

d. Port uncovered by helix.

(1) Pressure above plunger relieved through milled slot, metering recess, and back through inlet port.

(a) Injection ends.

(2) Overtravel phase-plunger still moves upward.

(3) Gives injection variable ending.

e. No fuel position.

(1) Milled slot aligned with inlet port.

f. Metering.

(1) Rotation of plunger varies time that helix uncovers port.

(a) The later the helix is uncovered, the more fuel is injected.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

g. Check valve.

(1) Opened by fuel pressure.

(2) Closed by spring and fuel pressure.

10. High pressure lines.

a. Made of steel.

b. All the same length and thickness.

11. Fuel injection valves.

a. Capsule type.

(1) Identification.

(a) Orifice size and part number stamped on capsule body.

(2) Component parts.

(a) Body.

(b) Nozzle assembly.

1. Filter screen.

2. Spring.

3. Injection valve and seat.

4. Spray tip.

(3) Operation.

  (a) Check valve opened by fuel pressure.

  (b) Closed by spring and combustion pressure.

  (c) Opens downward and closes upward.

  (d) 400-800 PSI atmospheric test opening pressure.

12. Precombustion chamber.

II.C.12. Use cutaway engine to explain, function and location of essential parts.

a. Concentrates and increases turbulence of compressed air adjacent to injection valve fuel discharge hole.

  (1) Increases atomization of fuel.

  (2) Can also contain glow plug for cold weather starting.

    (a) Used with direct electric starting.

13. Injection valve test demonstration.

a. Opening pressure test.

b. Spray pattern test.

c. Valve leakage test.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

NOTE: Item 13 is done by the instructor to satisfy the students curiosity. This demonstration is not intended to teach the student testing and adjusting of the Caterpillar nozzle.

D. Maintenance of the fuel system.

1. Diesel fuel tank.
   - a. Fueling.
   - b. Cleaning fuel strainer.
   - c. Cleaning filler cap breather element.
   - d. Removing sediment and water from tank.
2. Primary filter.
   - a. Cleaning.
3. Fuel filters and fuel filter housing.
   - a. Replacing filter elements.
   - b. Cleaning filter housing.
4. Removing and replacing injection pumps.
5. Locating a misfiring cylinder.
6. Replacing injection valve.
7. Priming (bleeding the fuel system.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

a. Engine must be turning through use of starting engine.

b. Bleed fuel filter housing.

c. Bleed all injection pumps together.

E. Caterpillar scavenging system.

1. Type of scavenging system.

a. Valve.

2. Flow of air, parts and functions.

a. Pre-cleaner.

(1) Removes major portion of foreign matter.

b. Air cleaner.

(1) Removes remaining foreign matter.

(a) Oil-bath type.

1. Uses engine oil and wire element.

(b) Dry type.

1. Replaceable paper element.

2. Said to be more efficient than oil bath.

3. Used on newest engines.

II.E.1. Use transparencies:

a. Valve trains.
b. Pre-cleaner.
c. Air cleaner.
d. Turbocharger.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Turbocharger and intake manifold.	II.E.2.c. Show turbocharger cutaway.	II.E.2.c. Students view cutaway in groups of 4 to see demonstration.
(1) Incoming air enters the center of the turbocharger impeller where it is compressed and forced into the manifold.		
(2) Air preheated in this manifold.		
(a) Through use of starting engine exhaust heat.		
(b) Starting engine exhaust manifold mounted inside diesel engine intake manifold.		
(c) The D-3306 utilizes glow plugs.		
d. Valves and valve mechanism.		
(1) Crankshaft.		
(a) Source of power.		
(2) Camshaft gear.		
(a) Provides rotary motion to camshaft.		
(3) Camshaft.		
(a) Equipped with one cam lobe for each valve.		

(4) Valve lifter.

(a) Changes rotary motion of camshaft to reciprocating motion.

(5) Compression release mechanism

(a) A mechanical device used to hold either the intake or the exhaust valves open to facilitate easier turning of the engine for starting purposes.

(b) 5 3/4" bore 6-cylinder engines open the intake valve.

(c) Opened by pushrod and cam arrangement acting on the valve rocker arm.

(d) Must be adjusted to .025 to .030" each time valves are adjusted. (NOTE: Always adjust AFTER valves are adjusted NEVER BEFORE).

(e) Compression release lever.

(f) Two positions of the compression release lever: (5 3/4" bore).

1. Start - all intake valves held off their seats.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

2. Run - no valves held open.

(6) Rocker-arm assembly.

(a) One shaft and six arms for each head.

(7) Sleeve.

(a) Receives side thrust of the rocker arm.

(8) Valve springs retainers and locks.

(a) Springs.

1. Two for each valve - inner and outer.

(b) Retains and locks.

1. Hold the springs compressed around valve stem.

(9) Valve rotators.

(a) Rotate valve approximately 3^{o} each time it is opened.

(b) Component parts.

1. Seating collar.

2. Spring washer.

541

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3. Retainer body.

4. Five steel balls on an inclined surface.

(c) Not employed on older engines.

(10) Valve guides.

(a) Guides valve through cylinder head.

(b) May be pressed out of head and replaced.

(11) Valve seats.

(a) Driven into cylinder head.

(b) May be replaced.

(12) Valves.

(a) One intake and one exhaust valve per cylinder.

(b) Located in cylinder head.

(c) 45 degree face.

e. Exhaust manifold and turbine housing of turbocharger.

(1) Manifold bolted to cylinder head.

(2) Directs exhaust gases from exhaust ports to stack or to turbocharger.

(3) The exhaust gases passing over the turbine wheel forces the turbine wheel to turn which in turn turns the impeller.

f. Exhaust stack.

(1) Leads exhaust gases to atmosphere.

(2) Fitted with a rain cap.

F. Cooling and lubricating systems.

1. Flow of coolant, components and functions.

a. Radiator lower tank.

b. Water tank.

c. Cylinder block - coolant passes through water jackets extending almost full length of cylinder liners.

d. Portion of coolant passes into starting engine cylinder block.

(1) Starting engine cylinder head.

(2) Returned to diesel engine cylinder head.

e. From diesel cylinder block water passes through water directors.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Diesel engine cylinder heads - coolant is directed into contact with valve parts and precombustion chambers.		
g. Water mainfold (external).		
h. Water temperature regulators (closed).	II.F.1.h. Pass thermostat among students for better understanding.	II.F.1.h. Examine thermostat and pass on to other class members.
(1) Water temperature regulators remain closed until engine reaches operating temperature.		
(2) When regulators are closed, coolant flows through bypass water tube to the inlet side of water pump.		
i. Water temperature regulators (open).		
(1) Engine coolant at operating temperature.		
(2) Coolant passes through water line.		
j. Radiator upper tank.	II.F.1.j. Take class to shop - point out cooling and lubricating systems service points.	
(1) Sealed pressure overflow.		
(a) Located in expansion tank of radiator.		
(b) Maintains pressure in cooling system of approximately 6 PSI.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(c) Prevents overflow on incline operation.

(d) Raises coolant boiling point 3 1/4 degrees F. for each pound of pressure.

(2) Testing the water temperature regulator.

(a) Remove regulator from housing.

(b) Suspend the regulator by a string or piece of wire in a pan of water with a thermometer.

(c) Heat the pan of water, stirring the water to maintain uniformity.

(d) Observe opening temperature of regulator. The opening temperature should be between 160 degrees and 170 degrees F. Regulator should be fully opened at 183 degrees F.

(e) If defective, replace.

(3) Cleaning thermostat.

(a) Accumulations of rust and scale may restrict the action of the regulator.

(b) Regulator may be disassembled for cleaning.

k. Radiator core.

l. Radiator fan.

m. Radiator fan bracket.

n. Fan belts.

2. Functions and characteristics of the lubricating system.

a. Oil pan (sump).

(1) Mounted on the bottom of the cylinder block.

(2) Made of cast iron.

(3) Inspection plates incorporated on sides of oil pan for inspection, repair and cleaning of the oil pump, main suction bell and pressure relief valve.

(4) The oil pumps are mounted in the pan and are driven by the crankshaft gear.

b. Suction bell.

(1) Floating screen.

c. Oil pump.

(1) Controlled inlet-type oil pump.

(2) Gear type, positive displacement.

(3) Tractor engines use a triple oil pump same as earlier models with exception of inlet valve and the pressure relief valve.

  (a) The inlet valve.

    1. An oil passage from the oil manifold returns oil to a spring-loaded piston, which acts as a valve.

    2. As the oil pressure on the piston increases, the piston is moved over the inlet to the pump, reducing the amount of oil entering the pump and in this way preventing a further rise of pressure.

(4) Pressure relief valve.

  (a) Spring loaded ball type.

  (b) Located on discharge side of pump to prevent excessive pressure when oil is cold or restricted.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) This valve is set to open at 90 PSI and is non-adjustable.		
d. Vertical passage in block.	II.F.2.d. Use actual engine to show and tell.	
e. Oil filter base. (1) Oil cooler by-pass valve.		
f. Oil cooler. (1) Water cooled type (heat exchanger).		
g. Oil filter base. (1) Oil filter by-pass valve.		
h. Oil filters. (1) Full-flow type. (a) All oil is forced through a replaceable element before going to engine parts. (2) Oil filter by-pass valve. (a) Valve located in filter housing oil manifold. (b) Opens to by-pass oil directly to engine parts if filter element should become clogged.		

(c) Ball check and spring type.

i. Oil manifold (main oil gallery).

(1) Crankshaft and main bearings.

(a) Connecting rod bearings.

(b) Piston pins and bushings.

(c) Spray to underside of piston crown.

(2) Tube from gallery lubricates rocker assemblies.

(a) Valve stem bushings and push rods.

(b) Valve lifters and cam lobes.

(c) Camshaft and bearings.

j. Oil pressure gauge.

(1) When the engine is warm and running at rated engine speed, the gauge should register in the "operating range" (Green).

(2) Lower pressure reading is normal at low idling speeds.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) If, for any reason, gauge ceases to register, the engine should be stopped immediately until difficulty is determined and corrected.		
k. Cylinder walls and pistons.		
l. Oil pump drive.	II.F.2.1. Have students refer to appropriate section of Caterpillar Operation and Maintenance Instructions Manual.	II.F.2.1. Refer to text as directed by instructor.
(1) From engine gear train.		
G. Maintenance of Caterpillar diesel engine.		
1. Starting engine maintenance.		
a. Ignition system.		
(1) Adjust magneto points.		
(2) Timing magneto engine.		
(3) Clean, adjust and test spark plugs.		
b. Fuel.		
(1) Clean sediment bowl and filter screen.		
(2) Clean fuel line filter.		
c. Carburetor adjustments.		
(1) Idle speed.		
(2) Idle mixture.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) High speed mixture.		
d. Adjust valves.		
e. Clean air cleaner.		
f. Clean crankcase breather.		
g. Change engine oil.		
h. Checking and changing transmission oil.		
i. Adjustment of clutch.		
j. Check pinion throw-out speed.		
k. Check for water, oil and gasoline leaks.	II.G.1.k. Demonstrate valve adjustments on starting engine and diesel engine using engines in shop.	II.G.1.k. Follow demonstration refering to job sheet.
2. Scavenging system maintenance.		
a. Clean pre-cleaner.		
b. Clean air cleaner.		
c. Adjust valves (diesel engine).		
d. Adjust compression release push rods.		
e. Check exhaust stack rain cover.		
3. Cooling system maintenance.		
a. Adjust fan belts.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Grease fan bearing hub and pump drive shaft bearing.		
c. Grease front engine support bearing.		
d. Clean dirt and debris from radiator fins.		
e. Water leaks.		
4. Lubricating system maintenance.		
a. Crankcase.		
(1) Oil change procedure.		
(2) Filter change procedure.		
(3) Crankcase breather, cleaning.		
(4) Checking for oil leaks.		
5. Hour meter.		
a. Importance to maintenance program.		
b. Location and interpretation of readings.		
6. Fuel system maintenance.	II.G.6. Direct student practice in servicing Caterpillar diesel engines.	II.G.6. Practice servicing Caterpillar diesel engines under direction of instructor.
a. Tank.		
(1) Draining of sediment.		
(2) Cleaning filler strainer.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Cleaning filler cap elements.		
b. Fuel filter housing.		
(1) Fuel gauge, use in determining filter conditions.		
(2) Fuel filters, changing.		
(3) Draining and washing of filter housing.		
c. Priming fuel system.		
7. General checks and service.		
a. Loose nuts and bolts.		
b. Air leaks.		
c. Fuel leaks.		
d. Oil all linkage.		
III. Application.		
A. Service Caterpillar diesel engines using appropriate handtools, special tools and shop equipment. Service the cranking system, fuel system and adjust engine valves. All performance will meet manufacturer's specifications as specified in job sheet without error.	III.A. Direct, supervise and evaluate student performance in servicing the Caterpillar diesel engine in compliance with manufacturer's specifications as specified in job sheet CM "A" JS 2.1.1.1, "Maintenance of Caterpillar Diesel Engines".	III.A. Service Caterpillar diesel engine while meeting manufacturer's specifications as specified in job sheet CM "A" JS 2.1.1.1 without error.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

IV. Summary.

- A. Type of fuel system.
- B. Flow of fuel and purpose of units.
- C. Parts and functions.
- D. Maintenance of the fuel system.
- E. Caterpillar scavenging system.
- F. Cooling and lubricating systems.
- G. Maintenance of Caterpillar diesel engine.

V. Test:

- A. End of unit written test.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: International Diesel Engine Operation

Average Time: 2 Periods (Class), 2 Periods (Pract)

Instructional Materials:

A. Texts:

1. Service Manual International 429 Series Diesel Engine, Form ISS1503D (portion of complete manual).

2. Service Manual IHC Roosa-Master Fuel Injection Pump.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

    a. Mechanics handtools.

    b. International special tools.

    c. Diesel engine shop equipment.

2. Equipment:

    a. Major.

Terminal Objective: Upon completion of this unit each student will be able to operate and service International diesel engine model 429 while working as a member of a two (2) man team. He will use all appropriate handtools, special tools, and shop equipment. These tasks will consist of engine operation followed by service to the fuel system, cooling system and lubricating system. All performance will comply, without deviation, to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1.1, "Maintenance of International Diesel Engine".

Enabling Objectives: Upon completion of this topic each student will be able to prestart check, start, operate and secure International diesel engine model 429 while working as a member of a two (2) man team. Additionally, he will monitor instruments and interpret readings. All performance will conform without error to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1.1, "Maintenance of International Diesel Engines".

Criterion Test: Prestart check, start, operate and secure International diesel engines while monitoring instruments and interpreting readings. All performance will conform, without error, to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1.1, "Maintenance of International Diesel Engines".

(1) International Model UDT 429 Diesel Engine (4 each).

3. Materials (consumable).

    a. Cleaning solvent.

    b. Diesel fuel.

    c. Diesel engine oil.

    d. Wiping rags.

D. Training Aids and Devices:

1. Film slides.

    a. Slide series, Roose-Master Fuel Injection System.

2. Locally Prepared Material:

    a. Job sheet.

        (1) CM "A" JS 2.2.1.1, "Maintenance of International UDT 429 Diesel Engines".

    b. Programmed Instruction.

        (1) Roosa-Master Fuel Injection System.

3. Devices.

    a. Roosa-Master Fuel Injection Pump (cutaway).

E. Training Aids Equipment:

1. 35mm slide projector.

Homework: Read:

1. Service Manual International 429 series Diesel Engine, Form ISS1503D (read entire operations section).

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: International Diesel Engine Operation.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:		
1. The new 429 International diesel engine differs from the old TD-9, TD-14, TD-18 and TD-24 engines in that the 429 starts directly on diesel and does not have to be started on gasoline.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. In this lesson you will learn the proper method of making the pre-start checks, how to start the International engines, and how to properly secure them. If this procedure is not followed, serious damage to the engine can result.		
3. You will be taught these steps in the classroom, and you will be graded on how you apply this knowledge in actually starting, running and securing these engines in the shop.		
4. Suggestions for the instructor:	I.D.4. State lesson objective.	
a. Stress importance of proper operation of International diesels. Point out that many of the failures that occur to these engines are due to improper starting and securing procedures.		
II. Presentation.	II. Pass out books and necessary literature.	
A. Description of International diesel engines.		
1. Four-stroke cycle.		
2. Cylinder block arrangements.		
a. In-line.		
b. Six cylinder.		
3. Engine classification.	II.A.3. Allow students to look through books to satisfy curiosity.	II.A.3. Review books received.

OUTLINE OF INSTRUCTION

a. Designated by tractor or utility application.

(1) Tractor TD-20.

(2) Utility UDT-429.

B. Components and functions for starting.

1. Engine throttle control knob.

a. Controls speed of engine.

(1) Maintains a uniform engine speed under variable loads.

2. Tachourmetre.

a. Upper half of indicator shows the engine RPM.

b. Lower half of indicator shows the indicated hours of engine operation.

3. Heat indicator (same as automotive application).

4. Ammeter (same as automotive application).

5. Engine oil pressure indicator (same as automotive application).

6. Ignition and starter switch.

a. Four positions.

INSTRUCTOR ACTIVITY

II.B. Take students to shop and demonstrate prestart, start, run and secure procedures.

STUDENT ACTIVITY

II.B. Observe operating procedures and take notes.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(1) "OFF".

(2) "ST" (Start).

(3) Two "ON" positions.

(a) Switch all the way to the left "ON" position provides electrical power to operate auxiliary electrical equipment while the engine is stopped.

C. Prestart check, starting, operating and securing IHC 429 engine.

1. Prestart checks.

a. Engine lubricant.

(1) Bayonet gauge marked on both sides.

(a) Engine running.

(b) Engine stopped.

(2) Checking crankcase oil level.

(a) Engine stopped - wait for oil to drain into crankcase pan before checking.

(b) Engine running - loosen oil filler cap to vent crankcase and provide balanced pressure and operate engine at low idle.

b. Coolant.

(1) One inch above baffle.

c. Diesel fuel.

d. Flush water trap.

(1) Remove drain valve in the water trap top.

(2) Reinstall drain valve when all water and sediment has been flushed from the water trap.

NOTE: Do not close the fuel shut-off valve or open any vents when flushing the water trap.

e. Check moving parts for obstructions.

(1) Tools.

(2) Rags.

(3) Parts.

(4) Personnel.

(5) Bar engine through at least two (2) turns.

(a) OBSERVE SAFETY PRECAUTIONS.

2. Starting.

a. Throttle control.

(1) Depress button in center of engine throttle control knob.

(2) Pull knob all the way out.

(3) Push knob back in until it is about one quarter way out.

b. Starting switch.

(1) Turn starting switch all the way to the right to the "ST" position.

NOTE: Crank engine for 30 seconds at a time. Allow the cranking motor to cool two or three minutes before cranking again.

c. Engine does not start or runs roughly.

(1) Vent fuel system.

(a) Open vent valve located on top of each fuel filter.

(b) Turn the ignition and starter switch to the "ON" position.

(c) Close first vent valve when clear fuel flows through it.

(d) Close the remaining vent valves as soon as clear fuel appears.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(e) Start engine.

NOTE: Allow the engine to run at 800 to 1200 RPM for 5 to 10 minutes to allow thorough distribution of the lubricating oil. The engine must not be placed under load until normal oil pressure is reached.

3. Operating procedure.

   a. Adjust throttle control knob.

      (1) Meet load requirements.

   b. Check instruments.

      (1) Proper readings.

4. Securing procedure.

   a. Operate engine at half throttle (no load) for three (3) to five (5) minutes.

      (1) Aids in cooling the engine and turbocharger before final shutdown.

      NOTE: Serious damage can result to the engine and turbocharger if the above step is neglected.

   b. Throttle control.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Push control knob all the way in.		
c. Ignition and starter switch.		
(1) Turn switch to the "OFF" position.		
D. Practical exercises in pre-start checking, starting, operating and securing the engine.	II.D. Direct student practice in operation of International UDT 429 Diesel Engine.	II.D. Practice operation of International 429 Diesel Engine.
E. Roosa-Master Fuel Injection Pump.	II.E. Hand out programmed instruction, Roosa-Master Fuel Injection System.	II.E. Students follow instructor with programmed instruction.
1. Type.		
a. Roosa-Master.		
b. "DC" pump double cylinder, opposed plunger inlet metering, distributor type.		
2. Pump model number system (sample model No. DBGVCC429-4C).		
a. "D" - basic model number.		
b. "B" - modification of "D" pump (second modification).		
c. "G" - type governor - flyweight (mechanical).		
d. "V" - method of mounting - vertical.		
(1) "F" would indicate flange mounting.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. "CC" - pump rotation - counter clockwise.		
f. "4" - number of cylinders.		
g. "29" - plunger diameter in inches - .290.		
h. "4C" - Application number.	II.E.2.h. Place serial number on C/B and explain interpretation.	II.E.2.h. Students answer questions asked by instructor regarding serial number interpretation.
3. Application.	II.E.3. Use slide series to show and explain operation of Roose-Master Fuel System.	
a. Although this fuel pump is a fairly recent addition to the fuel injection field, it is finding increasing application on a great many of the smaller high speed diesel engines. It has even replaced International Harvester's own fuel pump on all their new engines.	II.E.3.a. Utilize cutaway model of fuel pump to reinforce instruction.	
Some of the reasons for this pumps outstanding rise in popularity, are its small size and weight, relative inexpensiveness, simplicity of operation and repair, and its efficient operation at high speeds.		

b. In this lesson, you will be given the opportunity to obtain knowledge of its components and their operation, which will better help you in the troubleshooting and repair of this pump.

4. Pump components.

    a. Drive shaft.

        (1) Varies with applications.

            (a) May be keyed to gear in engine gear train.

                1. Not removed with pump.

        (2) Acts as driving member.

            (a) External splines engage with internal splines of distributor rotor.

    b. Lip seals.

        (1) Mounted on drive shaft.

        (2) One seal prevents engine oil from entering the pump.

        (3) Second seal retains fuel oil in the pump.

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    c. Distributor rotor.

        (1) Driven by pump drive shaft.

        (2) Drive end on "DC" pump rotor houses two diametric bores.

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d. Pumping plungers.

  (1) Four plungers.

    (a) Two large.

    (b) Two small.

  (2) Located in diametric bores of distributor rotor.

  (3) Actuated mechanically to create high fuel pressure.

e. Cam rollers and shoes.

  (1) Positioned on distributor rotor.

  (2) Transmits cam action to pumping plungers.

f. Leaf springs.

  (1) Two springs.

  (2) Secured to distributor rotor.

  (3) Retains cam rollers and shoes.

  (4) Limit maximum plunger travel.

g. Internal cam ring.

  (1) Located around distributor rotor.

  (2) Normally contains as many lobes as there are engine cylinders.

(3) Cause the pump plungers to move toward each other.

h. Hydraulic head.

(1) Composed of two units.

(a) Head barrel (outer).

(b) Head sleeve (inner).

(c) Head sleeve is press-fitted into the head barrel.

1. Normally inseparable.

(2) Mounts into pump housing.

(3) Contains bore in which rotor revolves.

(4) Houses internal fuel passages and charging ports.

i. Fuel line connectors.

(1) One for each cylinder.

(2) Connected with outlet ports in hydraulic head.

j. Fuel transfer pump.

(1) Vane type - positive displacement.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(2) Four pump blades or vanes.

(a) Spring loaded.

(3) Vanes driven by slots in distributor rotor end.

(4) Hydraulic head forms one surface for transfer pump.

k. End plate.

(1) Acts as a cover for the fuel transfer pump.

(2) Contains the following parts.

(a) Thrust plate.

1. Absorbs the thrust of the spring-loaded transfer pump blades.

(b) Pressure regulating valve assembly.

1. Sleeve controls pressure curve of transfer pump.

2. By-passes excess fuel from the transfer pump to the inlet side of the transfer pump.

l. Governor assembly.

II.E.4.1. Use slide to show governor assembly.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Mechanical flywheel - variable speed governor.		
(2) Function is to control or maintain a fixed governed engine speed.		
(3) Flyweights and retainer mounted on distributor rotor.		
(4) Governor flyweight action transmitted through sleeve to governor arm.		
(5) Governor arm linked to metering valve.		
m. Metering valve.		
(1) Regulates fuel flow to pumping chamber.		
(2) When closed, will stop fuel flow to pumping chamber.		
(3) Regulates fuel flow to automatic advance unit.		
5. Pump operation and fuel flow.	II.E.5. Show slide of fuel system flow.	II.E.5. Trace fuel flow as projected on screen.
a. Transfer pump.		
(1) Draws fuel from tank.		
(2) Fuel passes through inlet strainer housed in end plate before entering pump.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(3) Pump capacity greater than what is needed for injection.

  (a) Excess fuel by-passed through pressure regulating valve.

(4) Fuel not by-passed is forced into air vent cavity in the hydraulic head.

(5) Fuel under pump pressure is forced to flow through a drilled passage in the bottom of the air vent cavity into the annulus.

b. Annulus.

(1) Fuel passage machined in hydraulic head.

  (a) Between head barrel and head sleeve.

(2) Fuel enters at the bottom and is forced around the annulus groove to the top of the groove.

(3) At the top of the annulus the fuel enters a passage connecting it with the metering valve.

c. Metering valve and metering valve bore.

(1) Helical groove cut in metering valve.

(a) Permit fuel to enter charging ring.

(2) Quantity of fuel passing through the helical groove is regulated by the twisting or turning of the metering valve by the governor linkage.

d. Charging ring and ports.

(1) Square-like groove cut around the outside surface of the hydraulic head sleeve.

(2) A number of holes are drilled in the charging ring groove which allows for the exit of fuel.

(a) Holes are called charging ports.

(b) Number of charging ports depend on the number engine cylinders the pump must feed.

e. Angled passages.

(1) Located in distributor rotor.

(a) Fuel is discharged from the charging ports when two of the six charging ports in the charging ring line up with the two angled drilled passages in the distributor rotor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(b) Fuel at transfer pump pressure, flows through the two angled passages to the pumping cylinders.		
f. Pumping cylinders.		
(1) Transfer pump pressure forces plungers apart.		
(a) Rollers in cam ring valley.		
(2) Distance plungers separate or the quantity of fuel entering the pumping cylinders is controlled by the following factors:	II..E.5.f.(2) Instructor explain and define, insuring students completely understand.	II.E.5.f.(2) Students take notes.
(a) Fuel pressure at the charging ports.		
1. Controlled by the metering valve and by transfer pump pressure which varies with engine speed.		
(b) Time available for charging.		
1. Controlled by the length of time the charging ports in the hydraulic head remain in line with charging ports of the rotor.		

(c) Total plunger displacement available.

1. Controlled by the roller shoes contacting the adjustable leaf spring.

(3) Maximum distance plungers may separate limited by:

(a) Leaf spring.

g. Discharging.

(1) Rotor rotation carries angled passages out of index with charging ports.

(a) Rotor discharge port not yet lined up with an outlet port in the hydraulic head.

(b) Fuel trapped in the pumping cylinders.

(2) Rotor outlet port aligns with head outlet port.

(a) Cam rollers contact opposing cam lobes causing the plungers to move toward each other.

(b) Trapped fuel is forced through the axial passage in center of rotor unseating delivery valve.

(c) Fuel passes through outlet ports and lines.

1. To injection nozzle in cylinder.

h. Line retraction.

(1) Lowers line pressure to a predetermined point below nozzle opening.

(a) The cam is relieved to allow a slight outward movement of the roller before the discharge port is closed off.

(b) This action drops the pressure in the injection line enough to give sharp cut-off injection and prevent nozzle dribbling.

i. Return oil circuit.

(1) Fuel under transfer pump pressure travels through:

(a) Air vent cavity.

1. Upper part of air vent cavity connects with longitudinal passage called air vent passage.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(b) Air vent passage.

1. Connected with the governor linkage compartment.

2. Removes any air trapped.

a. Suction side leaks.

3. Provides lubricating fuel oil to governor linkage.

(2) Vent wire in air vent passage prevents fuel pressure loss.

(3) Excess fuel in housing is returned to the tank.

j. Pump lubrication.

(1) Lubricated by two small grooves located on either side of the charging port on the outside diameter of the distributor rotor near its flanged end.

(2) Grooves carry off fuel from the hydraulic head charging ports to the housing.

(3) Fuel lubricates the cams, rollers, governor part, etc.

(4) Absorbing heat and thus providing for pump cooling.

OUTLINE OF INSTRUCTION

(5) Excess fuel returns to the supply tank.

k. Governor operation.

(1) Throttle linkage.

(a) Mounted on body.

(b) Contains low and high idle adjusting screws.

(c) Throttle shaft travel is limited by the high idle adjusting screw.

(2) Governor control springs.

(a) Idle spring (lighter).

1. Regulates low-speed range.

(b) Governor spring (heavier).

1. Compressed by throttle linkage.

(3) Linkage hook.

(a) Acted on by both springs and weights

(b) Rotates metering valve.

INSTRUCTOR ACTIVITY

II.E.5.k. Show slide showing governor operation.

STUDENT ACTIVITY

II.E.5.k. Trace governor function as projected on screen.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(4) Governor weights.

(a) Forced out by centrifugal action.

(b) Move sleeve and governor arm.

1. Arm pivots on knife-edged shaft.

(c) Balances with spring action.

6. Optional accessories.

a. Automatic advance mechanism.

(1) Advances injection timing with speed or load increase.

(2) Permits retarded timing for starting.

(3) Employs movable cam ring and locating screw.

(4) Power piston actuated by increasing transfer pump pressure, moves locating screw and cam to advance position.

(5) Spring piston returns cam to retard position as transfer pump pressure decreases.

b. Electric shutoff.

  (1) Energized to run type.

  (2) Energized to shut-off type.

  (3) Employs a solenoid and armature mechanism.

c. Torque-control screw.

  (1) Provides a means of determining point of maximum engine torque.

    (a) High idle speed controlled by high idle screw adjustment and governor operation.

    (b) Full load governed speed controlled by metering valve contacting torque screw.

    (c) Maximum torque fuel.

      1. As engine slows down under load ports remain in register longer.

        a. More time given for transfer pump pressure to separate plungers.

        b. More fuel injected.

      2. Maximum fuel delivered determined by plunger leaf spring.

OUTLINE OF INSTRUCTION

F. Fuel injection nozzle.

1. Operating principles.

   a. Pressurized fuel from injection pump enters top of nozzle body.

   b. Fuel flows through passage in the valve body and nozzle spring retainer.

   c. Annular groove in the top face of the valve body fills with fuel.

   d. Two passages in the valve body direct the fuel around the valve.

   e. When fuel in the pressure chamber reaches a high pressure.

      (1) Spring force is overcome.

         (a) Controlled by shims.

      (2) Nozzle valve opens inward.

   f. Atomized fuel sprays from four orifice holes in nozzle tip.

   g. Injection ends.

      (1) Spring snaps valve shut on seat.

   h. Nozzle lubrication.

      (1) Fuel passes between valve stem and body.

INSTRUCTOR ACTIVITY

II.F. Show slide of fuel injection nozzle.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Fuel lubricates and cools the valve.		
(b) Carried off through center bore of spring retained and return passage in nozzle body.		
(c) Manifold connects all nozzles.		
1. Returns fuel to tank.		
2. Disassembly fuel injection nozzle and trace fuel flow through injection nozzle.		
G. Cooling system (construction).	II.G. Show slides of cooling system.	
1. Radiator lower tank.		
2. Water pump.		
3. Engine oil cooler, flywheel housing passage.		
a. Water from pump is directed through engine oil cooler and flywheel housing passage.		
4. Cylinder block.		
5. Cylinder head.		
6. Thermostat (same as automotive application).		
7. Radiator upper tank.		
a. Overflow tube is sealed by pressure valve assembly.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) Prevents water loss on incline operation.

(2) Permits higher altitude operation.

(3) Will open to release pressure in system if pressure exceeds predetermined valve setting.

8. Radiator core.

9. Radiator shutter (special application).

   a. Used to restrict air flow through radiator.

      (1) Cold weather operation only.

10. Radiator fan and fan bracket.

   a. Equipped with either section or pusher-type fans.

   b. Fan belt adjustment accomplished by:

      (1) Pulling generator away from block to tighten belt.

11. Fan belts.

   a. Check specification to obtain proper amount of fan belt slack.

   b. Always keep belt at correct adjustment.

H. Lubrication system (construction).

II.H. Show transparency and/or slides.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

1. Oil pan.

2. Oil pump screen.

3. Oil pump.

   a. Rotary gear type, positive displacement.

      (1) Pumping gears are helical-type gears.

4. Oil cooler.

   a. Core is replaceable.

5. Oil filters.

   a. Mounted to left side of crankcase.

      (1) Hang-down type.

         (a) Prevents dirt from getting into system when changing filter elements.

   b. Replaceable elements.

      (1) Impregnated paper.

      (2) Two elements.

   c. All oil going to engine parts passes through these filters.

      (1) Full-flow.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

d. Filter by-pass valve housed in each filter case.

   (1) Allows oil to go to moving parts of the engine in the event filter becomes clogged.

e. Filter header.

   (1) Directs oil directly to turbocharger.

6. Pressure regulating valve.

   a. Maintains an operating pressure of 44 PSI.

7. Oil manifold and other internal passages.

   a. Supplies oil to all moving engine parts.

8. Crankcase oil filler.

   a. Expandable rubber seal on filler cap.

9. Crankcase oil filler.

   a. Expandable rubber seal on dip stick.

10. Crankcase breather.

   a. Located above the push rod chamber covers.

      (1) Right side of engine.

   b. Breather element housed in crankcase.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Prestart check, start, operate and secure International diesel engines while monitoring instruments and interpreting readings. All performance will conform without error to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1.1, "Maintenance of International UDT 429 Diesel Engines".	III.A. Direct, supervise and evaluate student performance in conducting pre-start checks, starting, operating and securing International diesel engine while monitoring instruments and interpreting readings. All performance conforming to manufacturer's recommendations without error as specified in job sheet.	III.A. Perform prestart checks, start, operate, and secure International diesel engine while monitoring instruments and conforming to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1. Maintenance of International UDT 429 Diesel Engine.
IV. Summary.		
A. Description of International Diesel engines.		
B. Components and functions for starting.		
C. Prestart check, starting, operating and securing IHC 429 engine.		
D. Practical exercises in prestart checking, starting, operating and securing the engine.		
E. Roosa Master Fuel Injection Pump.		
F. Fuel injection nozzle.		
G. Cooling system (construction).		
H. Lubrication system (construction).		
V. Test:		
A. Written test to be given at end of this unit.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: International Diesel Engine Maintenance

Average Time: 11 Periods (Class), 18 Periods (Pract)

Instructional Materials:

A. Texts:

1. Operator's Manual, International UDT 429 Form 108520R1, International and Hough Construction Equipment, 401 N. Michigan Ave., Chicago, Illinois 60611 (entire manual).

2. Service Manual, Roosa-Master Fuel Injection Pump for International Diesel Engines, Form ISS1042D, International and Hough Construction Equipment, 401 N. Michigan Ave., Chicago, Illinois 60611, Sec. 1, pp. 5-7, Sec. 3, pp. 1-17.

3. Service Manual International 429 Series Diesel Engine Form ISS1503D, International Harvester Co., 401 N. Michigan Ave., Chicago, Illinois 60611, Sections 1, 2, 6 and 7.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

Terminal Objective: Upon completion of this unit each student will be able to operate and service International diesel engine model 429 while working as a member of a two (2) man team. He will use all appropriate handtools, special tools, and shop equipment. These tasks will consist of engine operation followed by service to the fuel system, cooling system and lubricating system. All performance will comply without deviation, to manufacturer's recommendations as specified in the job sheet CM "A" JS 2.2.1.1, "Maintenance of International Diesel Engines".

Enabling Objectives: Upon completion of this topic each student will be able to service International diesel engine model 429, while working as a member of a two (2) man team. He will use all appropriate handtools, special tools, and shop equipment. Specifically, he will service fuel injection system, scavenging system, cooling system and lubricating system. All tasks will conform to manufacturer's recommendations as stated in job sheet CM "A" JS 2.2.1.1, "Maintenance of International Diesel Engines".

Criterion Tests: Service International diesel engine fuel system, scavenging system and lubricating system while conforming to manufacturer's specifications as specified in job sheet without deviation.

Homework: Read:

1. Service Manual, Roosa-Master, Roosa-Master Fuel Injection Pump for International Diesel Engines Form ISS1042D, Sec. 1, pp. 5-7, Sec. 3, pp. 1-17.

   - a. Diesel engine handtools.
   - b. International special tools.
   - c. Diesel engine shop equipment.
- 2. Equipment.
   - a. Major.
      - (1) International UDT 429 Diesel Engine (4 each).
- 3. Materials (consumable).
   - a. Cleaning solvent.
   - b. Diesel fuel.
   - c. Engine oil.
   - d. Wiping rags.
   - e. International fuel filters.
   - f. International oil filters.
   - g. International air filters.

D. Training Aids and Devices:

- 1. Film slides.
   - a. International diesel engines.
- 2. Locally Prepared Materials:

a. Job sheet.

(1) CM "A" JS 2.2.1.1, "Maintenance of International UDT 429 Diesel Engine".

E. Training Aids Equipment:

1. 35mm slide projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: International Diesel Engine Maintenance.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives.	
1. In this lesson you are going to cover the maintenance of the IHC UDT 429 engine. You will have the opportunity to perform all the maintenance checks and minor adjustments which prolong the life of the equipment. A good maintenance mechanic can save the shop crew endless hours of repair work by doing a good job of periodic maintenance.	1. State information and materials necessary to guide student.	

2. The jobs you will do here in the school are identical to the work you will be expected to know and accomplish at your next duty station.

3. Suggestions for the instructor.

   a. Emphasize the importance of strictly following manufacturer's procedures and specifications.

   b. Urge student to use manufacturer's manual covering the specific model engine being serviced.

II. Presentation.

II.A. Show slide presentation on scavenging system.

A. Scavenging system maintenance.

1. Servicing air intake cap.

   a. Clean screen with compressed air.

      (1) If air is available, wash in clean hot water containing a small amount of non-sudsing detergent.

2. Servicing air filter element.

   a. Two methods.

      (1) Washing is preferred method.

         (a) Removes more dust and soot and restores element to almost new condition.

(b) Tap side or end of element against palm of your hand to remove loose dirt.

NOTE: Do not tap element against hard surface. This will damage element.

(c) Wash element in clean warm water with a small amount of non-sudsing detergent.

(d) Rinse element in clear water.

(e) Lay element on its side and allow to air dry.

NOTE: Do not try to remove excess water by using compressed air. Air will rupture wet element.

(2) Compressed air second method.

(a) Tap side or end of element against palm to remove loose dust.

(b) Direct clean dry compressed air up and down the pleats on the clean side of the element.

3. Valve adjustment.

II.A. 3. Show slide presentation on valve adjustment.

OUTLINE OF INSTRUCTION

a. Adjust valves with engine cold.

b. Remove valve cover.

c. Turn engine over until number on piston is on compression stroke.

  (1) Timing pointer on the front cover is in line with "TDC" mark on the vibration damper.

  NOTE: Piston is on compression when the push rods are loose and can be turned easily.

d. Adjust No. 1 - 2 and 4 intake valves and No. 1 - 3 and 5 exhaust valves.

  (1) Specifications (valve lash - cold).

    (a) Intake valves .012" - .014".

    (b) Exhaust valves .024" - .026".

  (2) Turn rocker arm adjusting screw in or out until correct feeler gauge clearance is obtained.

e. Turn crankshaft one complete revolution until "TDC" mark lines up with pointer again.

INSTRUCTOR ACTIVITY

II.A.3.a. Use chalkboard to demonstrate valve adjustment.

STUDENT ACTIVITY

II.A.3.a. Students take notes and/or make sketch.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Adjust No. 3-5-6 intake valves and No. 2-4-6 exhaust valves.		
g. Replace valve cover.		
NOTE: Valves may be adjusted in conventional manner - positioning piston TDC compression for cylinder to be adjusted.		
4. Exhaust stack and rain cover services.		
a. Keep free of obstructions.		
b. Rain cover must pivot freely.		
5. Turbocharger inspection.		
a. Inspect compressor wheel.		
(1) Check for soft carbon.		
b. Check connections to turbocharger.		
(1) Must be air tight.		
B. Lubricating system maintenance.	II.B. Show transparency.	II.B. Trace on screen.
1. Oil change procedure.		
a. Engine must be at operating temperature.		
b. Drain oil from oil pan.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

c. Refill pan to proper level (check bayonet gauge - engine stopped).

2. Filter change procedure.

a. Remove plugs and drain oil filter completely.

(1) Reinstall gaskets and plugs.

b. Clean filter header.

(1) Prevents dirt from dropping into cases during reassembly.

c. Unscrew the two filter case bolts.

(1) Remove cases and elements.

d. Discard elements and gaskets.

e. Wash filter cases thoroughly in solvent and dry.

f. Installation.

(1) Place new elements into cases.

(2) Add one quart oil to each case.

(3) Use new gaskets. Secure filter cases to header with bolts and washers.

(4) Torque to specified torque.

647 3. Cleaning of crankcase breather. 648

a. Remove two bolts which secure breather pipe to crankcase.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Remove breather element from crankcase.		
(1) Wash in solvent.		
(2) Dry thoroughly.		
c. Check breather pipe to be sure it is not plugged or restricted.		
d. Reinstall element, breather pipe and bracket.		
4. Inspection and correction of oil leaks.		
a. Inspect carefully.		
(1) Engine running and stopped.		
b. Determine cause of any lubricant leaks.		
c. Report to supervisor.		
C. Cooling system maintenance.	II.C. Show transparency.	II.C. Trace on screen.
1. Cleaning of radiator fins.		
a. With air or water pressure.		
b. Straighten any bent fins.		
2. Fan belt adjustment.		
a. 1/2 inch to 3/4 inch slack.		
b. Move generator out to tighten belts.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Water pump belt adjustment.		
a. 1/2 inch to 3/4 inch slack.		
b. Move idler out to tighten belt.		
4. Inspection and correction of water leaks.		
a. Inspect carefully.		
(1) With engine running and stopped.		
b. Determine cause of any water leaks.		
c. Report to supervisor.		
D. Hour meter.	II.D. Give students problems to work out.	II.D. Students work out problems.
1. Importance to the maintenance program.		
a. Assists in scheduling all preventive maintenance.		
2. Location and Interpretations of readings.	II.D.2. Refer to Operator's manual, form 1085250RI, page 7.	
a. Mechanical type - driven by engine gear train.		
(1) Number arrangement similar to speedometer.		
b. Indicator has a correction factor to determine actual hours of engine operation from indicated hours.		
(1) Example:		
(a) Engine RPM - 2000 (tachourmeter reading).		

(b) Indicated hours - 100 (hourmeter).

(c) To determine actual hours of operation, multiply the indicated hours (100) by the correction factor (.83).

(d) Actual hours: 83 hours.

E. Fuel system maintenance.

1. Fuel tank.

a. Fueling.

(1) End of work day.

(a) Removes warm air from tank.

(b) Lessens possibility of condensation.

(2) Clean cap before removing.

(3) Clean vent hole in cap.

(4) Check and clean filler hole screen if required.

b. Removing sediment and water.

(1) Open tank drain cock each morning.

(a) Heavy materials settle to bottom.

(2) Drain off about one quart of liquid.

2. Sediment trap, cleaning procedure.

a. Close fuel shut-off valve at fuel supply.

b. Loosen thumb nut under glass bowl.

(1) Remove bail, bowl and screen.

c. Wash bowl and screen in solvent.

(1) Remove all dirt and sediment.

d. Reassemble glass bowl, screen and bail.

(1) Tighten thumb nut by hand.

e. Open fuel shut-off valve and vent the fuel system.

(1) Follow the procedure for priming fuel system.

3. Replacing fuel filters.

a. Open bleeder valve.

b. Remove drain plug from filter case.

(1) Allow fuel to drain.

c. Unscrew retaining screw.

(1) Remove cover.

d. Remove and discard gasket and element.

e. Clean inside of the cover and case with diesel fuel.

f. Install new element in case.

g. Place new gasket into cover.

h. Place cover on case and tighten retaining screw.

i. Install drain plug and close bleeder valve.

j. Vent fuel system.

(1) Follow procedures for priming fuel system.

4. Priming and venting fuel system.

a. Check to see if there is an adequate supply of fuel in the tank.

(1) Open shut-off valves.

b. Units equipped with an electric fuel transfer pump.

(1) Turn ignition and starter switch to the "ON" position.

c. Open bleeder valve located on top of each fuel filter.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. When clear fuel (no appearance of air) flows from the first bleeder valve, close it.		
(1) Close the second bleeder valve as soon as clear fuel appears.		
e. Start engine.		
5. Locating a misfiring cylinder.	II.D.5. Demonstrate in shop prior to student participation.	II.D.5. Students take notes.
a. Loosen nut connecting fuel line to nozzle.		
(1) One at a time.		
(2) Listen for RPM drop.		
(3) Use rag to protect yourself from fuel spray.		
b. Cylinder which does not change engine RPM is misfiring.	II.D.5.b. Emphasize.	
6. Replacement of fuel injection nozzles.		
a. Remove fuel lines and plug openings.		
b. Remove fuel leakoff (fuel return) manifold from injection nozzle holders.		
c. Remove the two cap screws that hold down the injection nozzle holder.		
d. Remove nozzle holder from cylinder head.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

- e. Remove and discard seal washers for new one.
  - (1) These are compressible washers and should not be reused.
- f. Install injection nozzle holders.
  - (1) Be sure nozzle gasket is in bottom of nozzle sleeve.
- g. Torque injection nozzle holders.
- h. Install fuel leakoff manifold.
- i. Install fuel lines.

7. Engine compression test.

- a. Remove No. 1 injection nozzle holder from cylinder.
- b. Insert proper adapter into cylinder head.
  - (1) Secure adapter in place.
  - (2) Attach pressure indicator to adapter.
- c. Start the engine.
  - (1) Operate engine at 1,000 RPM.
  - (2) Check reading against specifications.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Check other cylinders in the same manner.		
d. Install each nozzle assembly after checking compression.		
8. High idle adjustment.		
a. Disconnect throttle linkage to the pump.		
b. Hold throttle lever all the way back to the rear.		
c. Adjust high idle stop screw until specified high idle speed is obtained.		
d. Connect throttle linkage.		
9. Low idle adjustment.	II.D.9. Instructor demonstration.	II.D.9. Students take notes.
a. Disconnect throttle linkage to pump.		
b. Move throttle lever of the pump forward until engine speed drops to 500-600 RPM.		
c. Turn the low idle stop screw in or out until the specified low idle speed is obtained.		
(1) Lock the locking nut.		
10. Transfer pump pressure test.		
a. Pressure must fall within a specified range.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) Check is made under no load conditions.

(2) High idle speed.

(3) Engine thoroughly warmed up.

b. Install 4068 gauge block assembly and 4072 fitting into the transfer pump pressure tap.

(1) Insert 4071 compound gauge assembly into 4068 gauge block.

c. Low pressure is the most common problem.

(1) Most common causes of low pressure are:

(a) Restricted fuel supply caused by pinched lines.

(b) Closed vent or dirty filters.

(c) Fuel supply air leaks in piping, filters, or end plate assembly.

(d) Worn transfer pump blades.

(e) Malfunctioning regulating valve.

(f) Scored pump liner or end plate.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

11. Suction side pump test.

    a. Restricted fuel supply.

        (1) Install 4078 gauge block and hose assembly in pump inlet.

        (2) Insert compound gauge.

        (3) Operate engine at high idle.

        (4) Read gauge for vacuum developed.

        (5) If reading exceeds 10 inches HG

            (a) Check for dirty filters, pinched or collapsed fuel line or a plugged vent.

    b. Fuel supply air leaks.

        (1) Operate engine at low idle.

        (2) Close fuel tank valve.

        (3) Read gauge for vacuum developed.

        (4) Reading should reach at least 20 inches HG.

            (a) Before engine stalls.

            (b) Reading should hold for several minutes after engine stops.

        (5) If vacuum reading is less than 20 inches HG when the engine stops and rapidly diminishes.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) There are air leaks.		
(b) Leaks may be found in the supply system or end plate assembly.		
(6) If vacuum reading is less than 20 inches when the engine stops and does not diminish.		
(a) Worn or malfunctioning transfer pump is indicated.		
12. Pump housing pressure test.	II.D.12. Instructor demonstration.	II.D.12. Students take notes.
a. Remove pump timing plate from pump.		
b. Make small hole in timing plate gasket.		
c. Secure 4068 gauge block, 4072 adapter and 4077 flange to side of pump.		
d. Operate engine at both low and high idle.		
e. Pressure should range between 6-8 PSI in the pump.		
(1) Outlet fitting in the pump cover is equipped with a spring-loaded ball check to maintain this 6-8 in the pump.		
(2) Pressure above these readings would indicate restricted fuel return line.		

OUTLINE OF INSTRUCTION

(a) Any restricted lines must be replaced.

F. General checks.

1. Bolts and nuts for tightness.

a. Head bolts.

(1) At operating temperature.

(2) In proper sequence.

b. Pan and valve cover bolts often neglected.

c. General check of all nuts and bolts.

2. Linkage lubrication.

a. Lubricate lightly all linkage not previously mentioned.

III. Application.

A. Criterion Test: Service International diesel engine fuel system scavenging system and lubricating system while conforming to manufacturer's specifications as specified in job sheet without deviation.

IV. Summary.

A. Scavenging system maintenance.

B. Lubricating system maintenance.

C. Cooling system maintenance.

INSTRUCTOR ACTIVITY

III.A. Direct, supervise and evaluate student performance in servicing the International UDT 429 diesel engine, conforming to manufacturer's specifications as specified in the job sheet CM "A" JS 2.2.1.1, without deviation.

STUDENT ACTIVITY

III.A. Perform maintenance services to IHC UDT 429 diesel engine while conforming to manufacturer's specifications as specified in the job sheet CM "A" JS 2.2.1.1, Maintenance of International UDT 429 Diesel Engine without deviation.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
D. Hourmeter.		
E. Fuel system maintenance.		
F. General checks.		
V. Test:		
A. End of unit written test.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: General Motors Diesel Engine Operation

Average Time: 4 Periods (Class), 2 Periods (Pract)

Instructional Materials:

A. Texts:

1. V-71 Engines, Detroit Diesel Operator's Manual, Form 6SE215 (current revision), Detroit Diesel Engine Division, GM Corp., Detroit, Michigan 48228 (portions of entire manual).

2. In-line 71 Engines, Detroit Diesel Maintenance, Form 6SE177, Detroit Diesel Engine Division, GM Corp., Detroit, Michigan 48228 (portions of entire manual).

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

2. a. Diesel engine handtools.

   b. GM special tools.

   c. Shop equipment.

Terminal Objective: Upon completion of this unit each student will be able to operate and service General Motors 71 series diesel engines while using appropriate handtools, special tools and materials. He will operate the engine and conduct service procedures to the fuel system, cooling system lubricating system and scavenging system with all tasks conforming without error to manufacturer's specifications and recommendations as specified in job sheet CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

Enabling Objectives: Upon completion of this topic each student will be able to operate a General Motors 71 series diesel engine. He will prestart check, start, run and secure the engine, while monitoring the instruments and interpreting readings to determine normal or abnormal function of engine systems as related to the two stroke cycle principles of operation. All tasks will be in accordance with manufacturer's specifications, without error, as outlined in job sheet CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

Criterion Test: Prestart check, start, run and secure GM 71 series diesel engine while monitoring the instrument, and interpreting readings to determine normal or abnormal function of engine systems as related to the two stroke cycle principle of operation. All tasks will be in accordance with manufacturer's specifications without error as outlined in the job sheet.

2. Equipment:

   a. Major.

      (1) GM V-6-71 Diesel Engines (6 each).

      (2) GM 6-71 in-line Diesel Engines (6 each).

3. Materials (consumable).

   a. Cleaning solvent.

   b. Diesel fuel.

   c. Diesel engine oil.

   d. Wiping rags.

D. Training Aids and Devices:

1. Film slides.

   a. Slide series: GM 71 Series Diesel Engine Construction.

2. Locally Prepared Material:

   a. Job Sheet.

      (1) CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

677 3. Devices.

   a. GM 3-71 Diesel Engine (cutaway).

   b. Disassembled roots-type blower mounted on board.

Homework: Read:

1. In-line 71 Engines, Detroit Diesel Maintenance, pages 4-17; V-71 Engines, pages 5-13.

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2. GM Unit Injector (cutaway).

E. Training Aids Equipment:

1. 35mm slide projector.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: General Motors Diesel Engine Operation.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives.	
1. We will study one of the two-stroke cycle diesel engines used in heavy equipment today.		
2. This engine has a unique fuel system, however it is basically the same as the two systems we have studied before.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. We will learn that there are no intake valves in this engine, and that there are two or four exhaust valves per cylinder. You will also learn why this is so, and the next week in this phase you will put this knowledge to practical use in the field and shop.	I.D.3. Pass out necessary books and job sheet.	
II. Presentation.		
A. Description of General Motors diesel engine.		
1. Two-stroke cycle.		
a. One power stroke per cylinder for every revolution of crankshaft.		
b. Two-stroke cycle is less economical to operate, but takes up less space.	II.A.1.b. Explain two-stroke cycle principle of operation.	
c. Produces 70 to 80% more power than a four-stroke cycle engine of equal bore and stroke.		
2. Cylinder block arrangements.	II.A.2. Use slides as necessary to show and explain operation of GM 71 series diesel engine.	II.A.2. Take random notes as needed.
a. V blocks.		
b. In-line blocks.		
(1) Only 71 series to be studied.		
3. Engine classification (71 series, in-line).		
a. GM Diesel 1-71, 2-71, 3-71, 4-71 and 6-71.		

(1) First digit indicates number of cylinders.

(2) Second and third digits indicate cubic inch displacement per cylinder.

b. Bore and stroke.

(1) 4 1/4" bore, 5" stroke.

4. Engine classification ("V" 71 series engines).

a. GM Diesel 6V-71, 8V-71, 12V-71 and 16V-71.

(1) First digit indicates number of cylinders.

(2) Second digit indicates "V" block arrangement.

(3) Third and fourth digits indicate cubic inch displacement per cylinder.

b. Bore and stroke.

(1) 4 1/4" bore, 5" stroke (same on all "71" series engines).

B. Principles of operation.

1. Compression stroke.

a. Every up-stroke of piston.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Air-blown in on bottom of stroke.		
2. Power stroke.		
a. Every down-stroke of piston.		
b. Exhaust occurs near bottom dead center.		
3. Intake and exhaust strokes for four-stroke system eliminated.		
4. A roots-type blower supplies air to the cylinder for scavenging and charging the cylinder with fresh air.	II.B.4. Use board mounted exploded view of disassembled blower to show and explain operation of roots-type blower.	
a. The blower is driven by the engine gear train and turns at approximately 2 to 1 ratio of crankshaft rotation.		
b. Has 2 rotors with 3 intermeshing lobes.		
(1) Spiral cut produces even air flow and reduces noise.		
c. Traps air between rotors and housing and forces it into the air box.		
(1) Produces approximately 7 PSI at maximum RPM.		
d. Provides drive for various accessories.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) In-line engines. (a) Fuel transfer pump. (b) Governor. (c) Water pump. (2) "V" engines. (a) Fuel transfer pump. (b) Governor.		
5. Air box. a. Is cast into the engine block and inter-connects all cylinders and receives air from blower. b. Air box drains. (1) Lowest points in the air box. (2) Vents air box contaminents to atmosphere. c. Air pressure in box is from 2-5 PSI.	II.B.5. Use cutaway engine to show engine construction.	
6. Inlet ports. a. Located in the lower end of each cylinder liner. b. Allow air to pass from air box to cylinders when uncovered by piston.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

- c. One row of large round holes ("V" engines).
- d. Three different designs (in-line engines).
  - (1) Two rows of small round holes.
  - (2) One row of large round holes.
  - (3) One row of figure eight holes.
    - (a) All liners interchangeable in any 71 series engine.

7. Exhaust valves.
   - a. Two exhaust valves per cylinder (in-line engine).
   - b. Two or four valves per cylinder depending upon engine application ("V" engines).
   - c. Overhead arrangement.
     - (1) Rocker arm and push rod actuated.

8. Scavenging (uniflow).
   - a. Pressurized air clears cylinder of exhaust gases and charges cylinder with fresh air.
     - (1) Exhaust valves and intake ports must be opened to accomplish scavenging.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

9. Compression stroke.

   a. Compression starts, when exhaust valves close, at approximately 55° after bottom dead center.

   b. The exhaust valves close after the inlet ports are covered, this engine is not "supercharged".

   c. Compression ratio of this engine is about 17 to 1.

10. Injection of fuel.

    a. Fuel is injected, just prior to the top of piston travel, directly into the combustion chamber.

       (1) Therefore employs an open combustion chamber.

    b. Employs a multiple orfice spray tip, for better atomization.

    c. Accomplished by a unit-type injector.

11. Power stroke.

    a. The burning fuel forces the piston down thereby creating the power stroke.

    b. The exhaust valves open as the piston is about halfway down, thus ending the power stroke.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
12. Ratio between camshaft and crankshaft.		
a. 1 to 1.		
13. No "buddy throws".	II.B.13. Emphasize and discuss.	II.B.13. Participate in class discussion.
a. Creates a minor problem of finding engine positions.		
(1) For valve adjustment and injector timing.		
14. Purpose of balance shaft.		
a. Timed to engine gear train.		
b. Eliminates excessive engine vibration.		
(1) Caused by high engine RPM.		
C. Pre-start check, starting, operating and securing 71 series GM diesel engines.	II.C. Take class to shop and demonstrate procedures for pre-start checking, starting, operating and securing GM 71 series diesel engine.	II.C. Observe demonstration and take notes.
1. Pre-start checks.		
a. Lubricating oil.		
(1) Dip stick markings - "full".		
(2) Must be checked with engine stopped.		
b. Diesel fuel.		
(1) Check level and fill with proper grade of fuel oil.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(2) Be sure shut-off valves are open from tank to engine.

c. Coolant.

(1) Check level and fill.

(2) Radiators filled with anti-freeze, room should be left for expansion.

d. Position throttle.

(1) Closed.

e. Emergency shut-down valve.

(1) Make sure cable is pushed all the way in.

(a) Pull out for emergency shut-down only.

f. Check exposed moving parts to see that they are free from obstruction.

(1) An engine that has not been in operation should be jacked thru one complete turn before starting to make sure all engine parts are free.

(2) Observe all safety precautions for engines used in different applications.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

2. Starting the engine.

a. Warm weather starting.

(1) Push engine shut-down cable in.

(2) Turn ignition switch to "ON" position (if equipped).

(3) Set the throttle in the idle position.

(4) Push starter switch until engine starts.

(a) Never operate starter for more than 30 seconds at one time.

b. Cold weather.

(1) If an ether starting aid is installed on this unit, it is a pressure-capsule type.

(a) Operation.

1. Remove cap.

2. Insert capsule in container.

3. Pull piercing shaft all the way out.

4. Tighten cap on container.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

5. Push piercing shaft all the way down.
   a. Rupture capsule.
   b. Fills container with starting fluid.
6. Move engine throttle to maximum speed position.
7. Pump ether into air intake, at the same time press starting switch.
8. When engine starts, push pump plunger all the way in until it locks.
9. Remove capsule from container.
10. Failure to start.
    a. If engine does not start after several trys, troubleshoot to determine cause.

(2) Air heater.

(a) Operate the heater pump, press the heater switch and starter switch at the same time.

(b) Small amount of fuel will burn in air box heating the intake air.

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OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

3. Operating the engine.

   a. As soon as engine starts, observe engine oil pressure gauge.

      (1) If no pressure within 10-15 seconds, stop engine.

      (2) Normal pressure reading is between 30-60 PSI.

   b. Run engine at partial throttle and no load for approximately 5 minutes to allow engine to warm up.

   c. As temperature increases, apply light load.

   d. Never apply full load until engine is up to normal operating temperature.

      (1) Normal operating temperature is from 160° to 185°F.

   e. Unnecessary idling.

      (1) Long periods of idling will lower coolant temperatures as there is incomplete combustion of fuel.

      (2) This unburned fuel causes crankcase dilution, lacquer and gummy deposits on valves and piston rings, also poor fuel economy.

OUTLINE OF INSTRUCTION

4. Securing the engine.

   a. Disengage load.

   b. Reduce engine speed.

      (1) Allow engine to run at half speed or lower for 4 to 5 minutes or until temperature gauge is on lower side of operating range.

      (2) Provides sufficient lubricant, water and air for uniform cooling.

   c. Pull engine shut-down cable control.

      (1) This places fuel-control rack in the no fuel position.

   d. When engine stops, turn ignition switch to "OFF" position (if equipped).

      (1) If switch is left on, there is a constant drain on the battery by the instrument panel indicators.

   e. Emergency shut down.

      (1) If normal shut down procedures fail, pull emergency stop control out as far as it will go.

INSTRUCTOR ACTIVITY

II.C.4. Direct and supervise student practice in operation of GM 71 series diesel engines.

STUDENT ACTIVITY

II.C.4. Practice operation of GM 71 series diesel engines following job sheet procedures.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) This stop cuts off combustion air from blower.		
(3) If emergency stop is used, it must be reset manually, at blower, before restarting engine.		
NOTE: This device to be used only for emergency shut down.		
D. Fuel system (construction and function).	II.D. Use slide series to show construction of fuel system.	
1. Type of fuel system.		
a. Solid or mechanical.		
(1) Unit injector.		
(a) Accomplishes all five required functions.		
2. Flow of fuel.		
a. Tank.		
(1) Primary fuel supply source.		
b. Check valve.		
(1) Prevents drain back of system to tank.		
c. Fuel strainer or primary filter.		
(1) Some applications employ a cleanable strainer.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(2) Other applications employ a replaceable filter element.

(3) This strainer or filter becomes the first stage of cleaning the fuel in this system.

d. Fuel transfer pump.

(1) Type.

(a) Gear.

1. Positive displacement pump.

e. Secondary filter.

(1) Located on discharge side of transfer pump.

(2) Contains a replaceable element.

(3) This is the second stage of cleaning the fuel.

f. Inlet passage of (manifold lower).

(1) Cast into cylinder head on "V" and later in-line engines.

(2) Earlier in-line engines, manifold is bolted to cylinder head.

g. Inlet pipes (jumper lines).

II.D.2.g. Utilize cutaway injector to show construction.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(1) Connect inlet manifold to each injector.

h. Injector (high-valve type) and (needle-valve type).

(1) Fitted into a water-cooled copper tube in the cylinder head.

(a) Tube is flared to seal in head and then reamed for proper fit of injector.

(2) Injector mechanically operated by push rod and rocker arm from engine camshaft.

i. Outlet pipes.

(1) Connects the injector to outlet passage or manifold.

j. Outlet passage or (manifold upper).

(1) Directs recirculating fuel to restricted fitting.

(a) Return flow removes air, and helps cool the injector.

(2) Cast into cylinder head on "V" and later in-line engines.

(3) Earlier in-line engines, manifold is bolted to cylinder head.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
k. Restricted fitting. (1) Located at after end of outlet passage or outlet manifold. (2) Restricts flow of return fuel. (a) Assists in maintaining fuel pressure. (3) "T" fitting on "V" engines, 90° Ell on in-line engines. (4) Fuel passing through the fitting is returned to the tank.		
E. Functions and operation of the injector.		
1. Functions. a. Times fuel injection. (1) Reciprocating movement of plunger controls timing. (a) Rotary movement has a slight effect of timing because of upper helix. b. Meters fuel. (1) Rotary movement of plunger controls metering. (a) Changing effect stroke.	II.E.1. Use slides to show operation and construction of unit injector.	II.E.1. View slides and participate in discussion.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(b) No fuel to full fuel position.

c. Create injection pressure.

(1) Reciprocating movement of plunger controls this.

(a) During effective stroke.

d. Injects fuel.

(1) Spray tip valve spring controls pressure at which fuel will be injected.

e. Atomizes fuel.

(1) High pressure fuel forced thru tiny orifices cause good atomization.

f. Continuous bypass of fuel back to tank.

(1) Cools injector.

(2) Eliminates air in fuel system.

2. Operation.

a. Charging.

(1) Plunger retracted - both ports uncovered.

(a) Fuel fills bushing.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(2) Lower port covered by bottom of plunger.

(a) Trapped fuel escapes through central passage, metering recess and upper port.

c. Pumping phase (high valve).

(1) Both ports covered by plunger.

(a) Upper helix covers upper port.

(b) Trapped fuel forced past injector valve.

(c) Fuel forced through small orifices in spray tip.

(2) Determines timing of injection.

(a) Variable beginning.

d. Pump phase (needle valve).

(1) Both ports covered by plunger.

(a) Upper helix covers upper port.

(b) Fuel pressure opens check valve.

(c) Fuel in check valve cage, spring cage passages, tip passages and tip fuel cavity is placed under sufficient pressure to open needle valve.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(d) As soon as needle valve opens, fuel is forced through small orifices in spray tip in a highly atomized spray.

e. Over-travel phase.

(1) Lower port uncovered by lower helix - pressure relieved.

(2) Ending may be constant or variable.

f. Metering.

(1) No-fuel - rack all the way out.

(a) Cut in lower helix uncovers lower port before upper helix covers upper port.

(2) Idle to full fuel - plunger rotated by rack to meet engine requirements.

(a) The longer ports are covered (effective stroke) the more fuel in injected.

(b) Maximum output of injector determined by cut of helixes (not plunger diameter).

3. Identification of injector (high value).

a. Size of injector indicate by metal tag.

II.E.3. Show students injectors with various identification marks - pass injectors among class members.

II.E.3. Examine injectors and participate in discussion.

OUTLINE OF INSTRUCTION

(1) HV 5 orange tag on body.

(2) HV 6 blue tag on body.

(3) HV 7 black tag on body.

(4) HV 8 green tag on body.

(5) HV 9 yellow tag on body.

F. Cooling system (flow).

1. Radiator lower tank.

   a. Water at this point should be coolest in the system.

2. Oil cooler.

   a. Water flows first to the oil cooler after leaving the lower tank (in-line engines).

      (1) Water drawn from lower portion of radiator by water pump and forced through oil cooler ("V" engines).

   b. Water enters bottom of oil cooler housing.

   c. Passes up and around the oil tubes in the cooler.

   d. Out the top of the oil cooler housing.

INSTRUCTOR ACTIVITY

II.F.2. Point out to class cooling system components on cutaway engine.

STUDENT ACTIVITY

II.F.2. Follow instructor discussion and observe cutaway engine components.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

3. Water pump.

4. Cylinder block.

5. Water director nozzles.

   a. Water nozzles are used to direct the water to the valves, valve guides and exhaust ports.

      (1) Two double-jet nozzles are located between each pair of cylinders.

      (2) Two single-jet nozzles are installed at each end of the cylinder head.

6. Cylinder head.

   a. Water flows through connecting passages between the block and head.

   b. Cools injectors.

      (1) Injectors are installed in a thin-walled copper tube passing through the water space in the cylinder head.

   c. Dissipates heat away from the combustion chambers.

7. Water manifold.

   a. Water flows through openings directly over the exhaust ports into the water manifold. (In-line engines).

b. Hot water returns to the top of the radiator.

c. Vent valve (in-line engines).

(1) Located in forward end of water manifold.

(2) Used to vent cooling system of air which will cause hot spots.

5. Thermostat.

a. Located in front end of the water manifold (in-line engines).

(1) Thermostat housing connected to the front of the cylinder head on 6 "V" and 8 "V" engines.

c. Alternate path during "warm up" (in-line engines).

(1) By-pass tube.

(2) Water pump.

(3) Cylinder block.

(4) Cylinder head.

(5) Water manifold.

d. Alternate path during "warm up" (6 "V" and 8 "V" engines).

(1) By-pass tube.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

- (2) Water pump.
- (3) Oil cooler.
- (4) Cylinder block.
- (5) Cylinder head.
- (6) Thermostat housing.

9. Radiator upper tank.
    - a. Hot water passes through the thermostat housing into the upper tank under a baffle plate.
        - (1) Baffle plate prevents loss of water.
    - b. A seamless copper overflow tube is located in the upper tank.
        - (1) The tube serves as an overflow for excess water above the baffle plate.
10. Core.
11. Radiator fan and fan bracket.
    - a. Fan may be either pusher or puller type.
    - b. Bracket is adjustable to change belt tension.
12. Fan belts.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Usually two are used.		
b. Proper adjustment is important to efficient cooling.		
G. Lubricating system (flow).	II.G. Point out to class main components of lubricating system using cutaway engine.	II.G. Observe cutaway and participate in discussion.
1. Oil pan (sump).		
2. Oil pump.		
a. Type.		
(1) Gear, positive displacement.		
b. Type of mounting.		
(1) Mounted on No. 1 and No. 2 main bearing caps (in-line engines).		
(2) Mounted in crankshaft front cover (6 "V" and 8 "V" engines).		
(a) Cover also functions as the oil pump body.		
c. Method of driving oil pump.		
(1) Gear driven from the crankshaft (in-line engines).		
(2) Pump drive gear splined to a pump drive hub on the front end of the crankshaft (6 "V" and 8 "V" engines).		

d. Pressure relief valve (in-line engines).

   (1) Located in the oil pump body.

   (2) Valve opening pressure, 100 PSI.

   (3) By-passes excess oil from the discharge to the intake side of the pump.

e. Pressure relief valve (6 "V" and 8 "V" engines).

   (1) Mounted on the cylinder block.

   (2) Discharges excess oil directly to the oil sump.

   (3) Valve opening pressure 100 PSI.

f. Direction of rotation (in-line engines).

   (1) Can be changed for either a right or left hand rotation engine.

   (2) On the six (6) cylinder engines, change the position of the valve.

   (3) On the three (3) and four (4) cylinder engines, change the position of the valve and invert the pump cover.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

3. Oil filter.

   a. Type.

      (1) By-pass.

      (2) Full-flow.

         (a) Both use replaceable elements.

   b. Location.

      (1) In-line engines (full-flow type).

         (a) Bolted to the lubricating oil cooler adaptor.

         (b) 100% of the oil passes through the filter before going through the oil cooler.

         (c) By-pass valve located in the oil cooler adaptor will by-pass the oil to the engine oil cooler in case the filter is clogged.

      (2) In-line engines (by-pass type).

         (a) Bolted to side of engine block.

         (b) A portion of the lubricating oil is continually by-passed through the filter.

(c) Filtered oil is returned to the oil pan.

(3) 6 "V" engines (full-flow).

(a) Equipped with single filter.

(b) Mounted.

1. Directly to oil cooler adaptor.

2. Remotely mounted on the oil cooler cover or water pump housing and connected by flexible hoses to an adaptor or filter junction.

3. By-pass valve located in oil filter adaptor or in the case of remotely mounted filters, in the filter adaptor of filter junction.

4. Oil cooler.

a. Type.

(1) Harrison bellows type.

b. Location.

(1) On blower side of the engine (in-line engines).

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(a) Mounted on the right-hand side of cylinder block at the lowest front corner (6 "V" engines).

(b) Bolted to the oil cooler adaptor plate.

(2) 100% of the oil passes through the oil cooler before going to the engine.

(a) By-pass valve located in the oil cooler adapter plate will by-pass the oil to the engine in case the oil cooler is clogged.

(b) By-pass valve opens at 40 PSI.

(c) Oil in the radiator will usually indicate a faulty oil cooler.

5. Oil pressure regulator.

a. In-line engines.

(1) Located at the end of the vertical passage leading to the main horizontal oil gallery.

(2) Opens at approximately 45 PSI.

(a) By-passes oil to engine crankcase.

b. 6 "V" engines.

(1) Located at the end of a vertical oil gallery. Located at the front of the cylinder block on the side opposite the cooler.

(2) Opens at approximately 50 PSI.

(3) Discharges excess oil back into the sump.

6. Oil pressure gauge.

a. Indicates oil pressure in main oil gallery.

7. Main oil gallery.

a. Location.

(1) In-line engines.

(a) Blower side of the engine, running the full length of the engine block.

(2) 6 "V" engines.

(a) Middle of the engine block.

b. Distributes oil to.

(1) Main bearings.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

(2) Crankshaft.

(3) Connecting rod bearings.

(4) Connecting rods.

(5) Wrist pins.

(6) Sprays and cools the underside of the piston crown.

  (a) Return of oil to sump by gravity.

(7) Vertical and transverse passageways. (In-line engines.)

  (a) Directs oil to cam and balance shaft and bearings.

  (b) Cam intermediate bearings lubricated by a drilled camshaft and fed from end bearings.

  (c) Passages extend to cylinder head to supply secondary oil gallery.

(8) Diagonally drilled oil passages at the rear of the block (6 "V" engines).

  (a) Carry oil to the two rear camshaft end bearings.

(b) Oil flows through rifle drilled camshaft to intermediate and front-end bearings.

(c) Oil from camshaft intermediate bearings is directed against the camshaft lobes and cam rollers which run in an oil bath.

(9) Secondary oil gallery (in cylinder head).

(a) In-line engine.

1. Located on camshaft side of engine.

2. Send lubricating oil to following areas:

a. Rocker arm assemblies.

(1) Through drilled rocker arm support bolts.

b. Cam followers and camshaft lobes.

c. Camshaft pockets.

d. Blower upper pockets.

e. Governor driver assembly and water pump drive (front).

f. Blower drive gears (rear).

g. Gravity to sump.

(b) 6 "V" engines.

1. Located on camshaft side of each cylinder head.

2. Sends lubricating oil to following areas:

a. Rocker arm assemblies.

(1) Oil flows thru the lower end of the rocker arm shaft bolts and rocker arm shaft brackets.

b. Exhaust valves.

c. Cam followers.

(10) Blower drive gear.

(a) Bearing pressure lubricated.

(11) Gear train.

(a) Splash lubrication.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Criterion Test: Pre-start check, start, run, and secure GM 71 series diesel engine while monitoring the instrument, and interpreting readings to determine normal or abnormal function of engine systems as related to the two-stroke cycle principle of operation. All tasks will be in accordance with manufacturer's specifications without error as outlined in the job sheet.	III.A. Direct, supervise and evaluate performance in starting, operating and securing GM 71 series diesel engine while monitoring instruments and interpreting readings to determine normal or abnormal function. All performance in accordance with manufacturer's specifications without error.	III.A. Start, operate and secure GM 71 series diesel engine while conforming to manufacturer's specifications, without error, as specified in Job Sheet CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".
IV. Summary.		
A. Description of General Motors diesel engine.		
B. Two-stroke cycle operating principle.		
C. Pre-start check, starting, operating and securing 71 series GM diesel engines.		
D. Fuel system (construction and function).		
E. Flow of fuel.		
F. Cooling system (flow).		
G. Lubricating system (flow).	IV.G. Recap high points of lesson.	
V. Test:		
A. Test items from this topic will be included in the end-of-unit test.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: General Motors Diesel Engine Maintenance

Average Time: 10 Periods (Class), 16 Periods (Pract)

Instructional Materials:

A. Texts:

1. V-71 Engines, Detroit Diesel Maintenance, Form 6SE184, Detroit Diesel Engine Division, General Motors Corp., Detroit, Michigan 48228, Sec. 14.

2. In-line 71 Engines, Detroit Diesel Maintenance, Form 6SE177, Detroit Diesel Engine Division, General Motors Corp., Detroit Michigan 48228, Sec. 14 and 15.

3. Detroit Diesel Field Service Date (Military) Form 18SE51, Detroit Diesel Engine Division, General Motors Corp., Detroit, Michigan 48228, (portions of entire manual).

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

a. Diesel engine handtools.

b. GM diesel engine special tools.

Terminal Objective: Upon completion of this unit each student will be able to operate and service General Motors 71 series diesel engines while using appropriate handtools, special tools and materials. He will operate the engine and conduct service procedures to the fuel system, cooling system, lubricating system and scavenging system with all tasks conforming without error to manufacturer's specifications and recommendations as specified in job sheet CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

Enabling Objectives: Upon completion of this topic each student will be able to service General Motors 71 series diesel engines while using appropriate handtools, special tools and shop equipment. He will service the scavenging system, lubricating system, cooling system and fuel system. All tasks will conform to manufacturer's specifications without deviation as specified in the job sheet CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

Criterion Test: Service scavenging system, lubricating system, cooling system and fuel system of General Motors 71 series diesel engines using appropriate handtools, special tools and shop equipment. All tasks will conform to manufacturer's specifications without error.

Homework: Study:

1. V-71 Engines, Detroit Diesel Maintenance, Sec. 14.

2. In-line 71 Engines, Detroit Diesel Maintenance, Sec. 14 and 15.

c. Diesel engine shop equipment.

2. Equipment.

   a. Major.

      (1) GM V-6-71 diesel engines (6 each).

      (2) GM 6-71 in-line diesel engines (6 each).

3. Materials (consumable).

   a. Cleaning solvent.

   b. Diesel fuel.

   c. Diesel engine oil.

   d. Wiping rags.

   e. Fuel filters.

   f. Air filters.

   g. Oil filters.

D. Training Aids and Devices:

1. Film.

   a. MN-422A, "Diesel Engine Governors", Part I, (12 min.).

2. Locally Prepared Materials:

   a. Job sheet.

(1) CM "A" JS 2.3.1.1, "Maintenance of General Motors Diesel Engines".

3. Devices.

a. GM 3-71 diesel engine (cutaway).

b. GM Unit Injector (cutaway).

c. GM Roots type blower (components mounted on board).

E. Training Aids Equipment:

1. 16mm sound projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: General Motors Diesel Engine Maintenance.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Mechanic.		
D. Overview:	I.D. State learning objectives.	
1. In this lesson you are goint to put to work the knowledge obtained in many previous hours of study.		
2. In effect, you will practice jobs which you will actually be called on to perform at your next duty station.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Some of these jobs may seem unimportant and trivial, but keep in mind that maintenance is the "ounce of prevention" that is worth more than the "pound of cure".		
4. Suggestions for the instructor:		
a. The student has performed maintenance on the fuel system, it is suggested that it be reviewed in this lesson for information purposes.		
b. Emphasize the importance of strictly following manufacturer's specifications and procedures.		
II. Presentation.	II. Introduce and show film, MN44A, "Diesel Engine Governors", Part I.	II. View film.
A. Scavenging system maintenance.	II.A. Review and discuss high points of film.	II.A. Discuss high points of film.
1. Clean pre-cleaner.	II.A.1. Use Operator's Manual for reference.	II.A.1. Follow instructor's lecture and discussion.
2. Clean air cleaner.		
a. Maintain proper oil level if required.		
3. Check emergency shut down.		
a. For freeness of operation.		
4. Air box drain, cleaning.		
a. Check for possible obstruction.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) Direct atmospheric (tubes).

5. Check cold weather starting device (air heater).

   a. Fuel hand pump operation.

   b. Spray orifice.

   c. Clean and adjust coil points.

   d. Clean and adjust igniter.

6. Cold weather starting device (ether capsule).

   a. Clean ether chamber and lines.

   b. Check ether chamber cap and gasket condition.

7. Check condition and operation of exhaust pipe rain covers.

B. Lubricating system maintenance.

1. Oil change procedure.

   a. Drain while hot.

   b. Install and tighten drain plug.

   c. Clean around filler tube.

   d. Never over or under fill.

   e. Make final check of level after a ten minute running period.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Oil filter, cleaning procedure.		
a. Clean housing and base thoroughly.		
b. Install new element and gasket.		
c. Check for oil leaks after starting the engine.		
C. Cooling system maintenance.	II.C. Introduce and show film MC 144SC.	II.C. View film.
1. Purging cooling system of air (in-line engines).		
a. Engine stopped.		
b. Open vent in water manifold.		
c. Close vent when solid stream of water appears.		
2. Adjustment of fan belts.		
a. Older models, move generator.		
b. Newer models; adjust fan bracket.		
3. Greasing of fan bearings.	II.C.3. Discuss high points of film.	II.C.3. Participate in discussion.
a. Older models have grease fitting.		
b. Newer models require no greasing.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

D. Fuel system maintenance.
  1. Tank.
    a. Fueling.
      (1) End of day.
        (a) Remove moisture laden air.
    b. Removing sediment and water.
      (1) Start of day.
        (a) Overnight settling period.
  2. Fuel strainer.
    a. Cleaning.
      (1) Wash in solvent or gasoline.
    b. Clogged strainer.
      (1) Install new element and gasket.
  3. Fuel filters.
    a. Changing.
      (1) By hourly schedule.
      (2) Clean housing thoroughly.
      (3) Install new element and gasket.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Locating a mis-firing cylinder.	II.D.4. Demonstrate to class on live engine how to locate mis-firing cylinder.	II.D.4. Observe demonstration and take notes as necessary.
a. Run engine at idle speed.		
b. Depress follower on one injector.		
(1) Listen for RPM change.		
(2) No RPM change indicates mis-firing of cylinder.		
c. Repeat on all cylinders.		
5. Replacing injectors.		
a. Level rocker arms.		
(1) Remove hold down bolts and swing back.		
b. Remove injector hold down.		
(1) Pry injector from copper tube.		
c. Replace in reverse order.		
6. Valve adjustment (6V engines).	II.D.6. Demonstrate valve adjustment and injector timing operations using actual engines in shop.	II.D.6. Assist instructor as called on during demonstration.
a. Engine at normal operating temperature (160° - 185°F).		
(1) Allow an additional .002" clearance when setting valves cold.		
b. Governor stop lever in the No Fuel position.		
c. Remove valve cover.		

d. Position engine.

(1) Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

CAUTION: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left hand direction of rotation as the bolt will be loosened.

e. Check valve clearance (normal operating temperature).

(1) Use .013" GO -- .015" NO GO method.

f. Adjust valve clearance (cold).

(1) Loosen the push rod locknut.

(2) Place a .017" feeler gauge between the valve bridge and the valve rocker arm pallet.

(3) Adjust the push rod to obtain a smooth pull on feeler gauge.

(4) Remove feeler gauge, hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

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(5) Recheck the clearance. If the adjustment is correct, the .015" feeler gauge will pass freely between the valve bridge and valve rocker arm pallet, but the .017" feeler gauge will not pass through.

g. Adjust remaining valves in firing order.

7. Valve adjustment (in-line engines).

a. Engine at normal operating temperature (160°-185°F.

(1) Allow an additional .002" clearance when setting valves cold.

b. Place governor throttle control lever in the No-fuel position.

c. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

d. Adjust valve clearance (cold).

(1) Loosen push rod locknut.

(2) Place a .013" feeler gauge between the valve stem and the rocker arm.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Adjust the push rod to obtain a smooth pull on the feeler gauge.		
(4) Remove feeler gauge, hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.		
(5) Recheck the clearance, if the adjustment is correct the .011" feeler gauge will pass freely between valve stem and rocker arm, but the .013" feeler gauge will not pass through.		
e. Adjust remaining valves in firing order.		
NOTE: SAFETY PRECAUTION: Whenever a push rod has been disconnected from the rocker arm clevis, the push rod must be screwed back into the clevis until it is flush with the threaded portion of the clevis before the rocker arm is bolted back in place. Failure to do so may permit the piston to hit the head of the valve when the engine is turned over.		
8. Injector timing (in-line and 6V engines).	II.D.8. Show timing tool and use chalkboard to demonstrate.	II.D.8. Take notes/ sketches as necessary.
a. Use proper timing tool.		
(1) 1.460" - for S-70 and HV7 injectors. 1.484" - for HV6 injectors.		
b. Governor stop lever in no fuel position.		

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OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

c. Position engine.

  (1) Valves fully open on cylinder to be adjusted.

d. Check timing dimensions.

  (1) Distance from top of body to top of follower.

  (2) Timing tool in hole on top of body.

    (a) Insure that there is no dirt in hole prior to inserting tool.

  (3) Hold tool perpendicular to body.

    (a) The flat of the gauge toward the injector follower.

  (4) Extended portion of gauge should just clear the top of follower.

    (a) Follower too low - early injection.

e. Adjust the follower height.

  (1) Screwing push rod into clevice will permit follower to rise.

f. Time remaining injectors in firing order.

g. Move the governor stop lever to the "run" position and hold it at that position with light finger pressure.

h. Turn the inner adjusting screw of the No. 1L injector rack control lever down until a slight movement in the governor stop lever is noted.

i. Screw outer screw in until it bottoms lightly on the injector control tube.

j. Move the governor stop lever back and forth a few times and note a "rotating" movement of the injector control rack when the stop lever is moved to the "run" position.

k. Hold the stop lever in the "run" position and using a screwdriver press downward on the injector control rack.

   (1) Rack should tilt downward, and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

   (2) Adjust the inner and outer adjusting screws to obtain this condition.

   (3) At this point, No. 1L injector rack control lever is fully adjusted.

   (4) Tighten both the inner and outer adjusting screws and recheck adjustment.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

l. Remove clevis pin from fuel rod at left bank injector control tube lever.

m. Insert the clevis pin in the fuel rod on the right cylinder bank injector tube lever.

  (1) Adjust No. 1R injector rack the same way you adjusted No. 1L.

n. Adjust the remaining injector rack control levers.

  (1) Remove clevis pin from the fuel rods and the injector control tube levers.

  (2) Hold injector racks in the full-fuel position.

  (3) Turn down the inner adjusting screw of the injector rack control lever until the screw bottoms (injector control rack in the full-fuel position).

  (4) Turn down outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(5) While still holding control tube lever in the full-fuel position, adjust the inner and outer adjusting screws to obtain the same condition as outlined in step (11.) CAUTION: once No. 1L and No. 1R injector rack control levers are adjusted, do not try to alter their setting.		
o. When all injector rack control levers are adjusted, recheck their settings.		
p. Insert the clevis pin in the fuel rods and the injector control tube levers.		
9. Governor gap adjustment (in-line and 6V engines).	II.D.9. Demonstrate on cutaway.	II.D.9. Follow instructor demonstration on cutaway.
a. To insure that all the governor spring tension is being imparted to the weights through the lever and not to the housing.		
b. Remove the governor cover.		
c. Place the speed control lever in the maximum speed position.		
d. Measure gap between governor spring plunger and plunger guide.		
(1) Should be .006".		
e. Adjust gap.		

(1) Loosen the locknut and turn the adjusting screw until a slight drag is noted on the feeler gauge.

f. Hold the adjusting screw and tighten the locknut.

g. Install the governor cover.

NOTE: Insure that pin on governor control lever shaft sets into slot on differential lever when replacing cover.

10. Equalizing racks (6V engines).

NOTE: Position injection rack control levers with the throttle in the full fuel position.

NOTE: The letters "R" and "L" indicate the injector location in the right or left bank, viewed from the rear of the engine. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining left bank control levers.

a. Disconnect any linkage attached to the governor stop lever.

b. Back out the buffer screw 5/8".

c. Loosen all of the inner and outer injector rack control lever adjusting screws on both cylinder heads and both load limit device adjusting screws.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
NOTE: Be sure all injector rack control levers are "free" on the injector control tubes.		
d. Check for binding in the governor to control tube linkage by moving the linkage through its full range of travel with one hand on the stop lever and the other hand on one of the control tube levers.		
e. Remove the clevis pin from the fuel rod at the right cylinder bank injector control tube lever.		
f. Move the speed control lever to the maximum speed.		
11. Equalizing racks (in-line engines.)	II.D.11. Demonstrate rack equalization procedure using live engines in shop.	II.D.11. Observe demonstration and participate as directed by instructor.
a. Disconnect any linkage attached to the governor stop lever.		
b. Back out the buffer screw 5/8".		
c. Loosen all of the inner and outer injector rack control lever adjusting screws.		
NOTE: Be sure all injector rack control levers are "free" on the injector control tubes.		
d. Move speed control lever to maximum speed position.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

e. Move the governor stop lever to the "run" position and hold it at that position with light finger pressure.

f. Turn the inner adjusting screw of the No. 1 injector rack control lever down until a slight movement in the governor stop lever is noted.

g. Screw outer screw in until it bottoms lightly on the injector control tube.

h. Move the governor stop lever back and forth a few times and note a "rotating" movement of the injector control rack when the stop lever is moved to the "run" position.

i. Hold the stop lever in the "run" position and using a screwdriver, press downward on the injector control rack.

   (1) Rack should tilt downward, and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

   (2) Adjust the inner and outer adjusting screws to obtain this condition.

   (3) At this point, No. 1 injector rack control lever is fully adjusted.

(4) Tighten both the inner and outer adjusting screws and recheck adjustment.

j. Adjust the remaining injector rack control levers.

(1) Remove clevis pin from the fuel rods and the injector control tube levers.

(2) Hold injector control racks in the full-fuel position.

(3) Turn down the inner adjusting screw of the No. 2 injector rack control lever until the screw bottoms (injector control rack in the full-time position).

(4) Turn down outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

(5) While still holding control tube lever in the full-fuel position, adjust the inner and outer adjusting screws to obtain the same condition as outlined in step (9).

CAUTION: Once No. 1 injector rack control lever is adjusted, do not try to alter this setting.

k. When all injector rack control levers are adjusted, recheck their settings.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

1. Insert the clevis pin in the fuel rod and the injector control tube lever.

12. Idle and buffer spring adjustment.

    a. Start engine and run until warm.

        (1) Stop lever in run position.

        (2) Speed control lever in idle position.

    b. Adjust idle speed screw.

        (1) Loosen locknut and turn idle speed screw until engine idles at recommended idle speed.

        (2) Idle speed 550 RPM.

        (3) Hold idle speed screw and tighten locknut.

    c. Adjust buffer screw.

        (1) Engine at idle speed.

        (2) Turn buffer screw "IN" so that it contacts differential lever as lightly as possible and still eliminates engine roll.

        (3) Hold buffer screw and tighten locknut.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

NOTE: Do not raise engine idle speed more than 15 RPM with the buffer screen.

13. Load limit device adjustment (CV engines).

a. Mechanically limits the travel of the injector racks and thereby the fuel output of the injectors.

b. The load limiting device is adjusted after the engine tune-up is completed.

(1) Loosen load limit screw locknut.

(2) Back load limit screw out of the adjusting screw plate until 1" of the screw is below plate.

(3) Adjust load limit screw locknut so bottom of locknut is 1 3/4" from bottom of load limit screw.

(4) Loosen load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

(5) Thread the load limit screw into the adjusting screw plate until the locknut "bottoms" against the top of the plate.

(6) Hold injector rack control tube in the full-fuel position and place the load limit lever, against the bottom of the load limit screw. Then, tighten the load limit lever clamp bolts.

(7) Check to ensure that the injector racks will just go into the full-fuel position.

(8) Hold load limit screw to keep it from turning, then set the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate.

(9) Thread load limit screw into the plate until the locknut "bottoms" against the top of the plate.

(10) Hold load limit screw to keet it from turning, then tighten the locknut to secure the setting.

14. Fuel flow test.

a. Disconnect return line to tank.

b. Operate engine at 1200 RPM and measure amount of fuel flow into a container for one minute.

(1) 0.8 gallon of fuel per minute (6V engine).

(2) 0.5 gallon of fuel per minute (in-line engine).

c. Immerse tube in fuel and watch for air bubbles.

(1) Indicates leakage on suction side of pump.

(a) Failures, gaskets and lines.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

E. General checks.

1. Lubrication of all linkage.
    a. Throttle linkage.
    b. Shut down linkage.
    c. Injector control tube and levers.
    d. Tachometer and hourmeter drive cable.
2. Grease all fittings.
    a. According to type of grease required.
3. General tightening of all nuts, bolts and screws.
    a. Head bolts.
    b. Pan bolts.
    c. Air box covers.
        (1) Check specifications.
4. Check for leaks.
    a. Fuel.
    b. Oil.
    c. Water.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Criterion tests: Service scavenging system, lubricating system, cooling system and fuel system of General Motors 71 series diesel engines using appropriate handtools, special tools and shop equipment. All tasks will conform to manufacturer's specifications without error.	III.A. Direct, supervise and evaluate student performance in servicing scavenging, lubricating, cooling and fuel systems of GM 71 series diesel engine while conforming to manufacturer's specifications without error.	III.A. Service scavenging, lubricating, cooling and fuel systems of GM 71 series diesel engines using appropriate handtools, special tools, and shop equipment. All tasks conforming to manufacturer's specifications without error.
IV. Summary.		
A. Scavenging system maintenance.		
B. Lubrication system maintenance.		
C. Cooling system maintenance.		
D. Fuel system maintenance.		
E. General checks.		
V. Test:		
A. A written examination on this topic will be included in the end of unit test.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Cummins Diesel Engine

Average Time: 2 Periods (Class), 2 Periods (Pract)

Instructional Materials:

A. Texts:

1. Cummins Diesel Engines, Construction Industrial, Industrial Firepump, Logging, Mining, Railway, Generator, Operation and Maintenance, Bulletin No. 983711-OE, Cummins Engine Co., Inc., Columbus, Indiana 47201, Sec. 1.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools.

    a. Diesel engine handtools.

    b. Diesel engine shop tools.

2. Equipment.

    a. Major.

        (1) Cummins NH-250, Diesel Engines (6 each).

Terminal Objective: Upon completion of this unit each student will be able to operate and service the Cummins NH-250 diesel engine while using applicable handtools, special tools and shop equipment. Specifically, he will operate a Cummins diesel and service the fuel system, cooling system, and scavenging system. All tasks will meet manufacturer's specifications and recommendations without deviation as specified in Job Sheet CM "A" JS 2.4.1.1, "Maintenance of Cummins NH Diesel Engines".

Enabling Objectives: Upon completion of this topic each student will be able to operate a Cummins NH-250 diesel engine. He will prestart check, start, run and secure the engine while monitoring instruments and interpreting their readings. His performance shall conform to manufacturer's recommendations, without error, as specified in Job Sheet CM "A" JS 2.4.1.1, Maintenance of Cummins NH Diesel Engines".

Criterion Test: Prestart, check, start, run and secure the Cummins NH-250 diesel engine while monitoring instruments and interpreting readings. All performance shall conform to manufacturer's recommendations without error as specified in the job sheet.

Homework: Study.

1. Cummins Diesel Engine Operation and Maintenance Manual Bulletin 983711-OE, Sec. 1 and 5.

3. Materials (consumable).

   a. Cleaning solvent.

   b. Diesel fuel.

   c. Diesel engine oil.

   d. Wiping rags.

D. Training Aids and Devices:

1. Films:

   a. Turbocharger, 985566M, Cummins Engine Co.

2. Locally Prepared Material.

   a. Job Sheet.

      (1) CM "A" JS 2.4.1.1, "Maintenance of Cummins NH Diesel Engines".

F. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Cummins Diesel Engine Operation.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. The most satisfactory service can be expected from a Cummins Diesel Engine when the operation procedures are based upon a clear understanding of the engine working principles. Each part of the engine effects the operation of every other working part of the engine as a whole.		
2. Many pieces of Navy equipment have the Cummins NH diesel engine and with adequate maintenance, they will last the Navy many years. Maintenance of this piece of equipment will fall upon you at your next assignment.		
3. Advancement in rating exams contain many items concerning the Cummins diesel engine and therefore it is to your advantage to learn more about this engine here at CM School.	I.C.3. State learning objectives. a. State information and materials necessary to guide student.	

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
D. Overview:	I.D. Pass out manual.	
II. Presentation.		
A. Cummins Diesel Engine.	II.A. Explain Cummins diesel engine model and series.	
1. Four stroke-cycle, high speed, full diesel engine.	II.A.1. Refer students to the operations manual, "Cummins Diesel Engine H and NH Series, page 5 thru 9.	
2. Engine model.		II.A.2. Review and identify series and models.
a. NH-250.		
3. Engine specifications.		
a. Bore and stroke.		
(1) 5½" x 6".		
(2) CID 855.		
(3) Maximum horsepower - 250.		
4. Head design.		
a. Each cylinder head is for two cylinders.		
5. Valve arrangement.		
a. Two intake and two exhaust per cylinder.		
B. Prestart check starting, operating and securing.	II.B. Have class refer to operation and maintenance instructions.	II.B. Refer to text as directed by instructor.
1. Prestart checks.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Lubricating oil.		
(1) Note expandable rubber seal on dip stick.		
b. Diesel fuel.		
(1) Adequate supply.		
c. Coolant.		
(1) Fill completely.		
d. Hand cranking.		
(1) Bar engine through two complete revolutions.		
(a) To reveal frozen parts or liquid in cylinders.		
(2) Do not attempt to start engine by hand cranking.		
e. Throttle position for starting.		
(1) Idle position.		
f. Manual solenoid control.	II.B.1.f. Show and pass solenoid control to class.	II.B.1.f. Examine solenoid.
(1) Closed position.		
g. Electrical solenoid control.		
(1) Open position.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

h. Check exposed moving parts for possible obstructions.

   (1) Check completely around engine.

2. Starting.

   a. Warm weather starting.

      (1) Pull compression release (if so equipped).

      (2) Push starter button.

      (3) Close compression release (if so equipped).

         (a) After 3 or 4 seconds of cranking.

      (4) Release starter button when engine starts.

         (a) Never use starting motor more than 30 seconds before allowing it to cool 2-5 minutes.

   b. Cold weather starting.

      (1) Intake air preheater.

         (a) Turn glow plug switch to on position.

         (b) After 20 seconds, operate priming pump (40-60 PSI) and push starter button simultaneously.

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(c) If engine is equipped with compression release, it should be utilized for 3 or 4 seconds when starter button is pushed.

(2) Ether-compound metering equipment.

(a) Close shut-off cock on ether chamber.

(b) Insert ether capsule in chamber.

(c) Push chamber cap down sharply and tighten 1/4 turn.

(d) Wait 30 seconds.

(e) Push starter button and then open shut-off cock.

(f) Compression release should have been used if so equipped.

(g) After engine starts, close shut-off cock and discard empty capsule.

5. Operating.

a. Check gauges.

(1) Lub oil pressure.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(2) Generator charging rate.

b. Listen for unusual noises.

c. Warm up speed.

(1) 800-1000 RPM.

d. Warm up period.

(1) No load until water temperature reaches 140°F.

(2) 10 to 15 minutes at partial load.

(a) Not to exceed 1600 RPM.

(b) Until water temperature reaches 160°/165°F.

e. Accelerating and decelerating quickly.

(1) Permissable if situation warrants.

(2) Not permissable for "hot rod" effect.

(a) Causes unnecessary engine wear and twisting effort on crankshaft.

f. Partial load application.

(1) Assists in faster warm up.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
g. Full load application.		
(1) Permitted on a hot engine only.		
(a) Water temperature - 160°/165°F.		
(b) Lube oil temperature - 180°/225°F.		
4. Securing.	II.B.4. Stress the importance of proper securing of engine.	II.B.4. Take notes.
a. Remove all load from engine.		
b. Idle engine from 3 to 5 minutes.		
(1) For cooling off period.		
c. Turn off fuel solenoid switch (PT pump).		
(1) NEVER use compression release mechanism.		
(a) Excessive wear will occur on push rod sockets.		
d. Emergency shut down.	II.B.4.d. Issue Job Sheet CM "A" JS 2.4.1.1. Demonstrate prestart check, starting, operating checks and proper securing of engine. Supervise student practice in engine operation.	II.B.4.d. Observe demonstration following CM "A" JS 2.4.1.1. Take notes as necessary. Operate Cummins engines under supervision of instructor.
(1) PT pump.		
(a) Use normal shut down switch.		

STUDENT ACTIVITY

II.C. Take notes, ask questions where in doubt.

II.C.2. Open text to pages 1-2, 1-3 as directed by instructor.

II.C.2.a. Examine PT-G and PT-R pump.

c. P.T. pump.

  (1) Driven by engine gear train.

  (2) May be mounted to and driven by air compressor.

d. Manifold supply line.

  (1) Connects pump outlet to inlet fuel manifold.

e. Inlet fuel manifold.

  (1) Provides fuel flow to all injectors.

  (2) Drilled passage through cylinder heads.

  (3) Located below outlet fuel manifold.

f. Injector.

  (1) Identified as P.T. type injector.

    (a) Stamped with letters P.T.

  (2) Has upper and lower radial groove.

    (a) Permits entry and drain of fuel at injector.

g. Outlet fuel manifold.

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

(1) Returns fuel not injected to the fuel supply tank.

(a) By means of manifold drain line.

h. Fuel connectors.

(1) Used between cylinder heads.

(a) To bridge the gap between each inlet and outlet manifold.

i. Manifold drain line.

(1) Connects outlet fuel manifold with fuel supply tank.

j. Piping.

(1) Returns fuel from fuel pump cooling kit to fuel supply tank.

(a) Usually routed to manifold drain line.

D. Pressure - time hydraulic theory.

1. Pressure.

a. With pipe diameters and time durations being equal, more pressure on a liquid results in a greater flow.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Restriction.		
a. With fluid pressures and time durations equal, the less restriction encountered by a liquid the greater will be the flow.		
3. Time.		
a. With pipe diameters and fluid pressures equal, the longer the time a liquid is permitted to flow, the greater will be the flow.		
E. Parts and functions.	II.E. Show and explain parts and functions using P.T. fuel system operation and flow wall charts.	II.E. Participate in discussion.
1. Tank (designed to hold 95% of total capacity).		
a. Outlet connection.		
(1) Mobile equipment.		
(a) Outlet located in bottom of tank.		
(2) Stationary equipment.		
(a) Outlet located in top of tank.		
(3) Sediment area of one inch left at bottom.		
b. Location must be within specifications.		
(1) Refer to manufactuer's instructions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Fuel filter.		
a. Preferred location below fuel pump inlet.		
(1) As close to fuel tank as possible.		
(a) No higher than 18" above fuel pump inlet; no lower than 30" below fuel pump inlet.		
b. Replaceable type element.		
(1) Porous, pleated, chemically treated paper.		
c. Filter housing fitted with drain cock.		
4. Piping (filter outlet).		
a. Size must be to manufactuer's specifications.		
5. P.T. fuel pump.		
a. Fuel transfer pump.	II.E.5.a. Explain using wall chart and/or transparency.	II.E.5.a. Pick students at random to re-explain on screen.
(1) Gear type, positive displacement.		
(2) Located at rear of P.T. pump housing.		

(3) Driven by main shaft of pump.

(a) Turns at crankshaft speed.

(4) Pump output capacity.

(a) In excess of largest engine requirements.

b. Pulsation damper.

(1) Absorbs pulsations and smooths fuel flow through system.

(a) By means of internally mounted steel diaphragm.

c. Screen.

(1) Located at top of fuel pump.

(2) Equipped with spring and magnet.

(a) When used with standard automotive governor.

(3) Two screens mounted "piggyback".

(a) When used with MVS governor.

d. Governor.

(1) Mechanical flyball type.

(a) Standard automotive governor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Driven by mainshaft of pump.		
(3) Maintain sufficient fuel for idling with the throttle control in idle position.		
(4) Cuts off fuel to the injectors above maximum rated RPM.		
e. Shutdown valve.	II.E.5.e. Show and pass shutdown valve to class.	II.E.5.e. Examine shutdown valve.
(1) Purposes.		
(a) Stops flow of fuel to engine to accomplish engine shutdown.		
(2) Types.	II.E.5.e.(2) Explain operation of both.	
(a) Manual.		
(b) Electric.		
6. Inlet fuel manifold.		
a. Conducts fuel from P.T. pump to each injector inlet.		
(1) Internal common manifold leading to each injector inlet.		
7. Injector.	II.E.7. Pass out injector to class.	II.E.7. Examine training aid injector.
a. Functions.		
(1) Accomplishes metering.		

(a) Varying pressures through a constant size metering orifice.

(2) Times fuel injection.

(a) Through camshaft and rocker arm action.

(3) Creates injection pressure.

(a) Through camshaft and rocker arm action.

(4) Injects fuel.

(a) Downward stroke of injector plunger.

(5) Atomizes fuel.

(a) Through multiple orifice injector cup.

(6) Permits fuel circulation.

(a) Majority of fuel flows through the injector.

1. Cools injector.
2. Eliminates air in system.

(b) Annular groove of plunger permits fuel to flow from lower drain passage to upper drain passage.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Plunger remains bottomed until intake stroke.		
1. Fuel is circulating through in injector to cool injector and purge air from system.		
8. Outlet fuel manifold.		
a. Similar to inlet fuel manifold.		
(1) Larger in diameter.		
b. Carries return fuel back to supply tank.		
9. Aneroid control (employed on turbo-charged engines).	II.E.9. Use aneroid cutaway.	
a. Reduces fuel manifold pressure when air manifold pressure is insufficient to completely burn fuel charge.	II.E.9.a. Have students examine cutaway.	II.E.9.a. Examine cutaway.
(1) Prevents excessive smoking upon acceleration.		
b. Operation.	II.E.9.b. Explain the operation using chalkboard and trainig aid.	
(1) Start up stroke.		
(a) Plunger starts to rise.		
1. Approximately 20° A.T.C. of intake stroke.		

OUTLINE OF INSTRUCTION

(b) Fuel flows through drilling in body past check ball in barrel, through inlet drilling in barrel, and around sump area.

(2) Metering.

(a) Plunger continues rising.

(b) Metering orifice uncovered.

1. Approximately 45° A.T.C. of intake stroke.

(c) Fuel flows through a constant size metering orifice and metered into the cup.

1. Accomplished by varying pressures from the P.T. pump.

(3) Injection.

(a) Plunger is forced downward.

(b) Metering orifice becomes covered by plunger.

1. Check ball is seated momentarily in order to maintain a solid column of fuel in barrel's inlet drilling.

INSTRUCTOR ACTIVITY

II.E.9.b.(2) Refer class to operations manual, page 1-8 to 1-9.

STUDENT ACTIVITY

II.E.9.b.(2) Participate in discussion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Fuel is forced through cup orifices into cylinder.		
F. Cooling system.	II.F. Explain cooling system using wall charts.	
1. Parts and functions.		
a. Operation.	II.F.1.a. Refer class to page 1-12 of operations manual.	II.F.1.a. Participate in discussion.
(1) Water circulated by a centrifugal-type pump mounted on the gear cover end of the engine and driven by belts from the accessory drive.		
(2) Water circulates around the wet-type cylinder liners, through cylinder head and around the injectors sleeves.		
(3) Engine coolant cooled by radiator or by heat exchanger.		
(4) Heat exchanger and oil cooler are built as one in some units.		
G. Lubricating system.	II.G. Explain lubricating system using wall charts.	II.G. Participate in discussion.
1. Parts and functions.		
a. Pressure lubricated.		
b. Operation.		
(1) Oil pressure is supplied by a gear type lubricating oil pump.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

c. Parts.

(1) Oil pump.

(a) Located on the fuel pump side of the engine.

(b) By-pass valve.

1. Insurance against interruption of oil flow by a dirty or clogged element.

(c) External oil line.

1. Connect oil pump to oil pump sump.

(d) Oil header.

1. Delivers oil to moving parts.

(e) Pressure regulator.

1. Maintains pressure of 30-50 PSI.

H. Air system.

1. Type of scavenging system.

a. Valve.

(1) NH series engines use two exhaust and two intake valves per cylinder.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Methods of scavenging.		
a. Naturally aspirated.		
(1) No mechanical device used to assist air intake.		
(2) Air is drawn into cylinders by low pressure area created on down stroke of piston.		
b. Super charged with blower.	II.H.2.b. Show film #985566M, "Turbocharger".	II.H.2.b. Critique film.
(1) Roots blower supplies air to engine at a pressure greater than atmospheric.		
(a) Regardless of engine speed.		
(2) Blower turns approximately 1.8 to 1 engine speed.		
(a) Driven by engine gear train.		
(3) As engine speed increases.		
(a) Air pressure increases.		
c. Super charged with turbo.		
(1) The energy contained in exhaust gasses turn the turbine wheel.		
(2) Compressor wheel mounted to same shaft as turbine wheel.		
(3) As energy of exhaust gasses increase, turbine and compressor wheel speed increases.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Thereby increasing air pressure supplied to engine cylinders. (4) Speed of turbo not regulated by engine speed. 3. Cooling and lubrication of turbocharger. a. Cooled by engine coolant. (1) Engine water pump provides flow of coolant to and from turbocharger. b. Cooled and lubricated by engine lubricant. (1) Engine lubricant has a dual purpose. (a) Provide adequate lubrication for bearings and moving parts. (b) Carry away heat from turbocharger. III. Application.		
A. Prestart check, start, run and secure the Cummins NH 250 diesel engine while monitoring instruments and interpreting readings. All performance shall conform to manufacturer's recommendations without error as specified in the Job Sheet.	III.A. Direct, supervise and evaluate students on prestart check, starting, running, securing and instrument monitoring. Their performance must conform to manufacturer's recommendations without error.	III.A. Prestart check, start, run, monitor instruments and secure Cummins NH 250 following job sheet and manufacturer's recommendations without error.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

IV. Summary.

- A. Cummins diesel engine.
- B. Prestart check.
- C. Fuel system.
- D. Cooling system.
- E. Lubricating system.
- F. Air system.

V. Test:

- A. Material from this lesson will be covered in the end of unit written examination.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

Classification: Unclassified

Topic: Cummins Diesel Engine Maintenance

Average Time: 8 Periods (Class), 12 Periods (Pract)

Instructional Materials:

A. Texts:

1. Cummins Tune-up and Troubleshooting Bulletin, No. 983643-CE, Cummins Engine Co., Inc.

2. Cummins Diesel Engines, Construction, Industrial, Industrial Firepump, Logging, Mining, Railways, Generator, Operation and Maintenance Manual, Bulletin No. 983711-OE, Cummins Engine Co., Inc., Columbus, Indiana 47201 (portions of entire manual).

3. Aneroids, Cummins Bulletin No. 985608-R, Cummins Engines Co., Inc., Columbus, Indiana 47201, (portions of entire manual).

4. The Principles of a Mechanical Governor, Bulletin No. 983601, Cummins Engine Co., Inc., (portions of entire booklet).

5. Operation and Adjustment, P.T. Fuel System, Bulletin No. 983438-A, Cummins Engine Co., Inc., (portions of entire manual).

B. References: None.

Terminal Objective: Upon completion of this unit each student will be able to operate and service the Cummins NH 250 diesel engine while using applicable handtools, special tools and shop equipment. Specifically, he will operate a Cummins diesel and service the fuel system, cooling system, and scavenging system. All tasks will meet manufacturer's specifications and recommendations without deviation as specified in Job Sheet CM "A" JS 2.4.1.1, Maintenance of Cummins NH Diesel Engines.

Enabling Objectives: Upon completion of this topic each student will be able to service a Cummins NH 250 diesel engine while using appropriate handtools, special tools and shop equipment. Specifically, he will service the fuel system, cooling system, lubricating system and scavenging system. All tasks will conform to manufacturer's specifications as specified in the Job Sheet CM "A" JS 2.4.1.1 "Maintenance of Cummins NH Diesel Engines", without deviation.

Criterion Test: Service fuel system, cooling system, lubricating system and scavenging system of Cummins NH diesel engine. All tasks to conform to manufacturer's specifications as specified in the job sheet without deviation.

Homework: Study:

1. Cummins Diesel Engines Operation and Maintenance Manual, Bulletin No. 983711-OE, Sec. 2, 3 and 4.

C. Tools, Equipment and Materials:

1. Tools.

   a. Diesel engine handtools.

   b. Cummins diesel engine special tools.

   c. Diesel engine shop equipment.

2. Equipment.

   a. Major.

      (1) Cummins NH 250 diesel engine (6 each).

      (2) Cummins P.T. fuel injection pumps (12 each).

3. Materials (consumable).

   a. Cleaning solvent.

   b. Diesel fuel.

   c. Engine oil.

   d. Wiping rags.

   e. Fuel filters.

   f. Oil filters.

   g. Air filters.

D. Training Aids and Devices:

1. Films:

    a. OPE-001, "Operation Hour Glass", Cummins Engine Co. (27 min.).

2. Charts.

    a. Engine Cooling System, side view (Cummins).

    b. Engine Cooling System, end view (Cummins).

    c. Engine Lubricating System, side view (Cummins).

    d. Engine Lubricating System, end view (Cummins).

    e. P.T. Fuel System Flow.

    f. P.T. Fuel System Operation.

3. Locally Prepared Materials.

    a. Job Sheets.

        (1) CM "A" JS 2.4.1.1, "Maintenance of Cummins NH Diesel Engines".

4. Devices.

    a. Cummins P.T. Pump (cutaway).

E. Training Aids Equipment:

1. 16mm sound projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Cummins Diesel Engine Maintenance.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. In this lesson you will have the opportunity to put into actual use the various knowledge lessons that have been previously presented.		
b. Servicing the Cummins NH engine should be the highlight of this unit, especially now that so many Cummins engines are in the battalions, and it becomes very probable that this will be a large part of your assigned job at your next duty station.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Servicing the Cummins NH diesel engine.	II.A. Show film OPE-001, "Operation Hour Glass".	II.A. View film.
1. Factors determining maintenance intervals.	II.A.1. Review highlights of movie. Issue operation and maintenance manual #983711-OE. Direct students to proper page.	II.A.1. Open manual as directed by instructor.
a. Operating conditions.		
(1) Temperature.		
(a) Excessive heat.		
(b) Excessive cold.		
(2) Atmospheric conditions.		
(a) Damp.		
(b) Dusty.		
(c) Corrosive (salt air).		
b. Usage.		
(1) Light or intermittent.		
(a) Stop and go.		
(b) Long idling periods.		
(2) Heavy use.		
(a) Heavy loads - constant lugging.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(b) Multiple daily shifts.		
c. Schedule basis.		
(1) Fuel consumption.		
(a) Most accurate.		
(2) Hours operated.		
(a) Sets maximum limits.		
(3) Mileage.		
(a) Highway equipment.		
2. Lubricating system maintenance.	II.A.2. Direct students to operation and maintenance manual, page 2-6.	II.A.2. Open manual as directed.
a. Change oil.		
(1) Consider conditions and type filters employed.		
(a) Combination of by-pass with full flow filters extends change intervals.		
b. Change filter (with oil).		
(1) Bag type.		
(a) Replace - do not clean.		
(2) Screen type.		
(a) Cleanable - report any metal particles in filter.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Element type.		
(a) Usually found on by-pass filter.		
3. Fuel system maintenance.	II.A.3. Direct students to proper page in operation and maintenance manual.	II.A.3. Open manual as directed.
a. Tank.		
(1) Drain sediment.		
(2) Fill daily.		
b. Filters.		
(1) Drain according to conditions.		
(2) Change elements.		
c. Fuel pump.		
(1) Clean screen and magnet.		
d. Injectors.		
(1) Clean inlet screen.		
(2) Reverse flush.		
(3) Adjust.		
4. Cooling system maintenance.	II.A.4. Direct students to proper page in operation and maintenance manual.	II.A.4. Open manual as directed.
a. Adjust drive belts.		
(1) Pump mounted fan.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Eccentric mounted water pump.		
1. Rotate water pump body in bore.		
(2) Bracket mounted fan.		
(a) Adjust pump belts as above.		
(b) Adjust fan belts with bracket adjusting bolt.		
NOTE: New belts must be readjusted after 2 hours operation. Deflection depends on belt thickness and span - use manufacturer's specifications.		
b. Fan hub pulley.		
(1) Tighten.		
(2) Lubricate.		
c. Cleaning system.		
(1) Drain and flush.		
(2) Check hoses.		
(3) Clean radiator externally.		
5. Air system.	II.A.5. Direct students to proper page in operation and maintenance manual.	II.A.5. Open manual as directed.
a. Precleaner - construction equipment.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

b. Air and vapor line connections.

   (1) Check connections for leaks.

c. Air cleaner.

   (1) Oil bath.

      (a) Check oil level daily.

      (b) Change oil and clean mesh.

         1. Dry mesh thoroughly.

   (2) Dry type.

      (a) Clean with air only.

      (b) Check for holes.

   (3) Composite type.

      (a) Clean dust cup daily.

      (b) Clean cyclone funnels.

      (c) Clean dry element.

         1. With compressed air.

         2. No holes permitted.

d. Crankcase ventilation.

   (1) Oil bath type.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Oil level.		
(b) Clean screen (solvent).		
(2) Horsehair elements - turbocharged engines.		
(a) Clean with solvent and compressed air.		
(3) Paper element.		
(a) Chemically treated.		
(b) Naturally aspirated engines only.		
(c) Cannot be cleaned.		
3. General maintenance.	II.A.6. Direct students to the proper page in operation and maintenance manual.	II.A.6. Open manual as directed.
a. Starter.		
(1) Oil with 30 weight oil.		
(2) Blow dust out of housing.		
b. Generator.		
(1) Oil with 20 weight oil.		
c. Linkages.		
(1) Lubricate.		
(2) Check for binding.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Tighten all nuts and bolts.		
(1) Do not exceed torque specifications.		
e. Check for leaks.		
f. Wipe engine clean.		
(1) Wins operator's respect and cooperation.		
(2) Shows concern and good attitude.		
(3) Aids in locating leaks and loose parts.		
III. Application.		
A. Service fuel, cooling system, lubricating system, and scavenging system of Cummins NH diesel engine. All tasks to conform to manufacturer's specifications as specified in job sheet without deviation.	III.A. Direct, supervise and evaluate students performance in conducting maintenance to the Cummins NH diesel engine. Student must perform without deviation from Job Sheet CM "A" JS 2.4.1.1.	III.A. Perform service to fuel system, cooling system, lubricating system and scavenging system of the Cummins NH diesel engine following Job Sheet CM "A" JS 2.4.1.1.
IV. Summary.		
A. Factors determining maintenance intervals.		
B. Lubricating system maintenance.		
C. Fuel system maintenance.		
D. Cooling system maintenance.		
E. Air system maintenance.		
F. General maintenance.		
V. *Test:* Administer end of unit test.	V.A. Administer written exam, set time limit.	

MODIFICATIONS

Instructor Guides 25.1 & 25.2 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

Diesel

8-5

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION MECHANIC "A" SCHOOL TRAINING COURSE A-610-0022

INFORMATION SHEET

TITLE: Magnetos

A. Advantages.

1. Reliable.

    a. Requires little maintenance.

    b. Self-contained unit.

        (1) No external source of power.

B. Disadvantages.

1. Low voltage for starting.

    a. Coming-in speed.

2. Engine usually hand-cranked.

    a. No battery or charging system for cranking, or lights.

C. Source of electrical energy.

1. An electrical conductor, a magnetic field and the relative motion between the field and the conductor.

    a. Permanent magnet supplies the magnetic field.

    b. Wire coil is the conductor.

    c. Motion supplied by mechanical energy of the engine.

2. Two types of magnetos.

    a. Armature wound.

        (1) Coil moves while magnets are stationary.

        (2) Inductor type.

            (a) Magnets (horseshoe) moves and coil is stationary.

                1. Rotor, is the permanent magnet.

a. Used to direct the magnetic field flow through the windings. First in one direction then in the other direction.

D. Transforming device.

1. Coil windings. Primary and secondary. Same as battery ignition coil.

a. Rapid collapse.

E. Interrupting device.

1. Breaker points.

a. Breaks the primary circuit.

NOTE: One end of the primary winding is connected to ground; the other to the insulated breaker point. When the points are closed, the circuit is completed to grounds; when open, the circuit is broken. Lobes on cam actuate the breaker points, interrupting the primary circuit and timing the induction of maximum voltage in the secondary circuit. The cam is mounted on either the armature or rotating magnet.

F. Capacitor.

1. Prevents arcing of points.

a. Receives surge of current.

G. Distributor cap and rotor.

1. Similar to battery ignition system.

H. Impulse coupling.

1. Device for accelerating the motion during cranking.

a. Parts.

(1) Spring and ratchet.

(2) Pawl stop.

b. Action.

(1) Spring is wound against ratchet.

(2) When piston reaches TDC, spring is triggered (let go) automatically.

(3) Spring flips drive shaft of magneto with enough speed to produce current for one firing.

(4) As engine speed increases (starts) the coupling is locked out and magneto is driven normally.

NOTE: The impulse coupling provides the necessary speed of magneto for hand-starting of engine. Is normally locked out at about 100 RPM and is called coming-in speed.

I. Stop switch (shut-off).

   1. A grounding device of primary circuit (insulated point).

J. Maintenance and lubrication.

   1. Similar to distributor.

      a. Burnt points, faulty condensor or coil, loose connection.

K. Timing.

   1. Follow manufacturer's procedure.

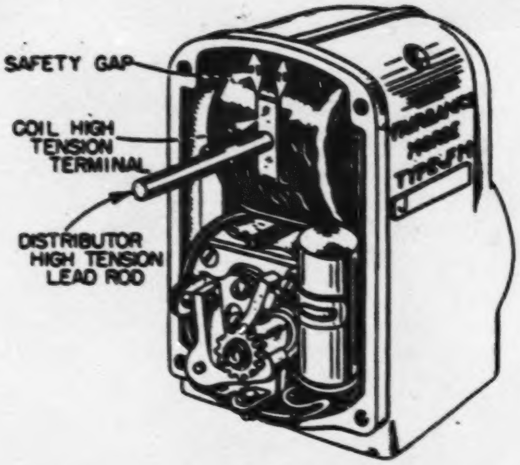
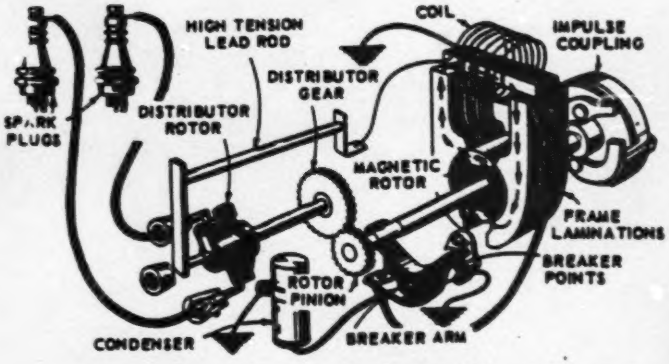

SAFETY GAP
COIL HIGH TENSION TERMINAL
DISTRIBUTOR HIGH TENSION LEAD ROD
FAIRBANKS MORSE TYPE FM

Fig. 35-61. Fairbanks Morse type FM, rotating magnet magneto.

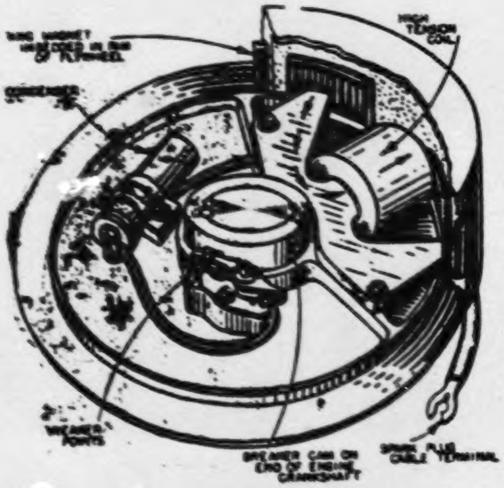

SPARK PLUGS
HIGH TENSION LEAD ROD
DISTRIBUTOR GEAR
DISTRIBUTOR ROTOR
COIL
IMPULSE COUPLING
MAGNETIC ROTOR
FRAME LAMINATIONS
BREAKER POINTS
ROTOR PINION
CONDENSER
BREAKER ARM

Schematic diagram of rotating magnet magneto.

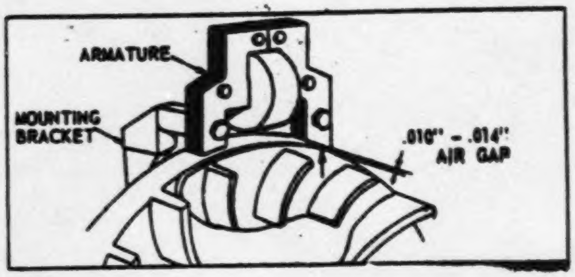
A Fairbanks Morse type FM magneto with cover removed is shown above Note gear for rotating magnet and breaker cam. These are built in a variety of designs for engines of various sizes and compression ratios.

Flywheel Magnetos

Flywheel magnetos, shown below are of the revolving magnet type and are used extensively for ignition on small internal combustion engines used on lawn-mowers, garden tractors, outboard motors, etc. For the most part, flywheel magnetos are used on single cylinder engines, but are also used occasionally on two and four cylinder engines.


RING MAGNET IMBEDDED IN RIM OF FLYWHEEL
CONDENSER
HIGH TENSION COIL
BREAKER POINTS
BREAKER CAM ON END OF ENGINE CRANKSHAFT
SPARK PLUG CABLE TERMINAL

Flywheel type magneto.


ARMATURE
MOUNTING BRACKET
.010" - .014" AIR GAP

Armature Air Gap

872

Diesel 499

CONSTRUCTION MECHANIC SCHOOL
U. S. NAVAL SCHOOLS, CONSTRUCTION JS 2.1.1.1
PORT HUENEME, CALIFORNIA 93043

CLASS "A"
COURSE A-610-0022

JOB SHEET

MAINTENANCE OF CATERPILLAR DIESEL ENGINES

INTRODUCTION:

A. The purpose of this job sheet is to guide you in the proper maintenance of the Caterpillar diesel engine.

B. You will perform maintenance and adjustments on the Caterpillar diesel engine.

C. You will accomplish this, using safety precations, in accordance with manufacturer's specifications.

TOOLS AND EQUIPMENT:

A. Basic mechanics hand tools

B. Caterpillar diesel engines

1. Model D-342

2. Model D-3306

CONDITIONS:

A. Student teams of three (3) students each are assigned to 2 Caterpillar diesel engines to accomplish maintenance procedures for this engine.

B. Each team is provided with all required tools and a job sheet covering the maintenance operation to be performed.

C. Preceding the shop performance all aspects of the job with necessary background theory is covered in the classroom lecture/discussion.

D. You will not omit any of the steps in the procedure, unless told to do so by your instructor.

E. You will complete all steps in the procedure to the "Instructor Check" point. DO NOT proceed beyond this point until your instructor has checked yourrwork and initialed your job sheet.

F. You will follow job sheet closely and in no way deviate from its procedure.

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G. You will obtain from the instructor clarification of step-by-step procedure that you are unfamiliar with.

H. Under no circumstances will you allow tools be placed on the engine or on the deck.

I. Cleanliness should be a matter of personal pride and it is essential in the handling of engine parts and tools, also the area in which you are working. Therefore, keep hands and tools wiped clean and keep the area in which you are working clean.

PROCEDURES:

NOTE: All performance will conform to manufacturer's specifications without deviation.

1. Prestart checks:
   - a. Diesel fuel supply (full)
   - b. Gasoline supply (full)
   - c. Radiator coolant level (above baffle plate).
   - d. Check all exposed moving parts to insure that they are free of obstructions and that all personnel are clear.
   - e. Check oil levels:
     - (1) Starting engine oil level (operating range).
     - (2) Diesel engine oil level (operating range).
2. Start, run, and secure engine: Instructor Check Point________
   - a. Position controls.
     - (1) Compression release in start position.
     - (2) Starting engine transmission in high range.
     - (3) Diesel engine throttle in closed position.
   - b. Open gasoline fuel shut-off.
   - c. Position starting controls.
     - (1) Idle latch engaged.
     - (2) Position choke as necessary.

(3) Magneto switch on. Instruction Check Point__________

d. Crank starting engine

(1) Use safe cranking technique. (Crank through top arc of travel only. Do not wrap thumb around handle).

e. Warm up starting engine, (run 3 to 5 minutes before engaging to main engine).

f. Release idle latch on starting engine.

g. Starting diesel engine.

(1) Engage starting engine pinion and clutch.

(2) Crank diesel engine until oil and fuel pressure is in operating range. Instructor Check Point___________

(3) Place compression release lever in Run position, throttle lever in approximately 1/2 position, (operation performed simultaneously).

h. Operating diesel engine

(1) Close gasoline fuel shut-off valve to starting engine.

(2) Allow starting engine to run until gasoline supply in carburetor is depleted.

(3) Allow diesel engine to run until temperature is in operating range.

(4) Secure diesel engine. Instructor Check Point_________

3. Adjustment of starting engine valves.

a. Position engine with spark plugs removed TDC Compression for cylinder to be adjusted.

b. Adjust valves to .008 hot - Intake and exhaust) (.007" Go, .009" No Go).

Instructor Check Point______________

4. Gap spark plugs:

a. Gap .030" using wire gauge.

Instructor Check Point_____________

(1) Gage should pass through plug gap with slight drag.

5. Magneto service. (Student remove magneto from starting engine. Remove distributor cover from magneto).

   a. Cleaning, inspection, and adjustment.

      (1) Clean distributor cap of all carbon dust.

      (2) Inspect for cracks and broken terminals.

      (3) Inspect contact points for damage.

      (4) Adjust contact points.

         (a) Position rubbing block on high part of cam.

         (b) Adjust clearance to .015" (014" Go, 016" No Go).

      Instructor Check Point_______________

      (5) Install distributor cover.

   b. Timing magneto to starting engine.

      (1) Install magneto with "X" mark on magneto impulse coupling aligned with "X" mark on engine drive.

      Instructor Check Point_______________

      (2) Tighten mounting bolts.

6. Adjustment of diesel engine valves:

   a. Remove valve covers.

   b. Position #1 cylinder TDC Compression observing valve action.

      (1) Valve clearance intake and exhaust .016" - (.015 Go - .017 No Go).

      (2) Compression release - .027" (.026 Go - .028 No Go)

Instructor Check Point_______________

   c. Continue valve adjustments following firing order.

Instructor Check Point_______________

   d. When adjustments are complete install valve covers, spark plugs in starting engine and wire magneto.

7. Adjust starting engine clutch:

   a. Adjust for definite over-center snap - Too loose
      Too tight

Instructor Check Point ________________

8. Bleed-fuel system:

   a. With diesel engine being cranked by starting engine, perform fuel system bleeding procedure.

      (1) Open lower bleed valve on filter housing, leave open until solid stream of fuel flows.

      (2) Open upper bleed valve on filter housing. Leave open until solid stream of fuel flows.

      (3) Open fuel pump vent valves until solid flow is observed then close valves.

   Instructor Check Point ________________

9. Cooperation with team mate:

   a. Gives and takes directions equally well.

   b. Correctly interprets instructions.

   c. Communicates in a friendly manner.

   d. Provides timely suggestions and assistance to team effort.

   e. Performs efficiently.

   Instructor Check Point ________________

10. Use of tools:

    a. Accurate tool selection.

    b. Safe application of tools.

    c. Reading and interpretation of special tools and measuring instruments.

   Instructor Check Point ______________

11. Shop safety:

    a. Handling of fuels.

    b. Handling of lubricants.

c. Handling of batteries.

d. Good housekeeping.

e. Observes posted safety precautions.

f. Conforms to smoking regulations.

g. No skylarking.

Instructor Check Point______________

12. Attitude:

a. Alertness and interest in training situation at hand.

b. Displays a genuine desire to participate.

c. Motivated towards learning.

Instructor Check Point___________

·505

Diesel

NAVAL SCHOOLS CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

CMA J. S. 2.2.1.1

TITLE:
MAINTENANCE OF INTERNATIONAL UDT 429 DIESEL ENGINES

Introduction

A. The purpose of this job sheet is to guide you in the proper maintenance of the International Diesel Engine.

B. You will perform maintenance and adjustments on the International Diesel Engine.

C. You will accomplish this, using safety precautions, in accordance with manufacturer's specifications.

Tools and Equipment

A. Basic mechanics handtools

B. UDT429 International Diesel Engines

Conditions

A. Student teams of three (3) students each are assigned to an International Diesel Engine to accomplish maintenance procedures for this engine.

B. Each team is provided with all required tools and a job sheet covering the maintenance operation to be performed.

C. Preceding the shop performance all aspects of the job with necessary background theory and demonstrations by the instructor are covered in the classroom lecture/discussion.

D. You will not omit any of the steps in the procedure, unless told to do so by your instructor.

E. You will complete all steps in the procedure to the "Instructor Check" point. DO NOT proceed beyond this point until your instructor has checked your work and initialed your job sheet.

F. Follow job sheet closely and in no way deviate from its procedure.

G. Obtain from the Instructor clarification of step by step procedure that you are unfamiliar with.

H. Under no circumstances will you allow tools to be placed on the engine or on the deck.

G. Cleanliness should be a matter of personal pride and it is essential in the handling of engine parts and tools, also the area in which you are working. Therefore, keep hands and tools wiped clean and keep the area in which you are working clean.

Procedures:

NOTE: All performance will conform to manufacturer's specifications without error.

A. Service Dry Type Air Intake Filter System

1. Air intake cap and screen

2. Air filter element

   a. Clean with compressed air or shake and wipe clean.

   Instructor check point ____________________

B. Adjustment of Valves

1. Adjust valves with engine cold

2. Throttle control and shut down in no fuel position

3. Remove valve rocker arm cover

4. Rotate engine until number one piston is on "TDC" compression stroke

   a. Timing pointer on the front cover is in line with "TDC" mark on the vibration damper.

   b. Piston is on compression stroke when the push rods are loose and can be turned easily; also rocker arm action on buddy cylinder can be observed.

   Instructor check point ________ ____________

5. Adjust the valves of .012" go and .014" no go on the intake valves and for .024" go and .026" no go on the exhaust valves.

6. Continue valve adjustment following the engine firing order and using the buddy throw method for determining TDC compression stroke.

   Instructor check point ______________________

C. Turbocharger Inspection

1. Remove exhaust pipe and air inlet pipe

2. Remove turbine and compressor covers

3. Inspect compressor and turbine wheels

   a. Check for soft carbon deposits; dirt build up, damaged blades interference or excessive end play

4. Clean with a coarse brush; do not bend or damage the blades on the wheels

5. Replace covers; maintaining original alignment; use care on "O" ring seals.

   Instructor check point________________________

6. Check connections to turbocharger; must be air tight

7. Battery connection

D. Service the Crankcase Breather

1. Remove two bolts which secure breather pipe to crankcase

2. Remove breather element from crankcase

   a. Wash in solvent

   b. Dry thoroughly

   C. Check breather pipe to be sure it is not plugged or restricted

   Instructor check point____________________

3. Reinstall element, breather pipe and bracket

E. Pre-start Checks, Starting, Operating and Securing the Engine

1. Engine lubricant

   a. Bayonet gauge marked on both sides

   b. Engine running

   c. Engine stopped

2. Checking Crankcase oil level

   a. Engine stopped - wait for oil to drain into crankcase before checking.

   b. Engine running - Loosen oil filler cap to vent crankcase and provide balanced pressure and operate engine at low idle.

   Instructor check point______________________

3. Coolant

   a. One inch above baffle

4. Diesel Fuel - Full

5. Flush water trap

   a. Remove drain valve in water trap top

   b. Reinstall drain valve when all water and sediment has been flushed from the water trap

   NOTE: Do not close the fuel shut-off valve or open any vents when flushing the water trap

   c. Use the electric priming pump to flush the water trap when the fuel tank is lower than the water trap.

Instructor check point______________________

6. Check moving parts for obstructions

   a. Tools

   b. Rags

   c. Parts

   d. Personnel

   e. Bar engine through at least two (2) turns

      (1) Observe safety precautions

7. Battery connection

   a. Check generator regulator for correct polarity and voltage

   b. Check specific gravity, above 1250 spg.

   c. Clean all terminals, tighten all connections

   d. Fasten the ground connection last

Instructor check point______________________

8. Starting

   a. Throttle control

   b. Depress button in center of engine throttle control knob

   c. Pull knob all the way out

   d. Push knob back in until it is about one-quarter way out

9. Starting switch

   a. Turn starting switch all the way to the right to the "ST" position

NOTE: Crank engine for 30 seconds at a time. Allow the cranking motor to cool two or three minutes before cranking again

b. Start engine

NOTE: Allow the engine to run at 800 to 1200 RPM for 5 to 10 minutes to allow thorough distribution of the lubrication oil. The engine must not be placed under load until normal oil pressure is reached

10. Operating procedure

a. Adjust throttle control knob

(1) Meet load or speed requirements

b. Check instruments

(1) Proper readings

Instructor check point______________________

11. Securing procedure

a. Operate engine at half throttle (no-load) for 3 to 5 minutes

NOTE: Serious damage can result to the engine and turbocharger if the above step is neglected

b. Throttle control knob

(1) Push control knob all the way in

c. Ignition and starter switch

(1) Turn switch to the "off" position

Instructor check point______________________

F. Venting and Priming the Fuel System

1. Check to see if there is an adequate supply of fuel in the tank

a. Open shut-off valve

2. Units equipped with an electric fuel transfer pump

a. Turn ignition and starter switch to the "on" position

3. Open bleeder valve located on top of each fuel filter

4. When clear fuel(no appearance of air) flows from the first bleeder valve, close it.

a. Close the second bleeder valve as soon as clear fuel appears.

Instructor check point ______________________________

G. Locating a misfiring cylinder

1. Loosen the nut connecting the fuel line to the fuel nozzle.
    - a. Loosen one at a time.
    - b. Listen for drop in engine RPM.
    - c. Use a rag for protection from fuel spray.
2. The cylinder which does not change engine RPM is misfiring.

Instructor check point ______________________________

H. Engine Compression Test

1. Remove one (1) injection nozzle holder from cylinder head.
2. Insert proper adapter into cylinder head.
    - a. Secure adapter in place.
    - b. Attach pressure indicator to adapter.

Instructor check point ______________________________

3. Start the engine.
    - a. Operate engine at 1,000 RPM.
    - b. Check reading against Mfg. specifications.
    - c. Check other cylinders in the same manner and record.
4. Reinstall each nozzle assembly after checking compression.
5. Compare all readings - To determine engine condition.

Instructor check point ______________________________

I. High Idle Adjustment.

1. Disconnect throttle linkage to the pump.
2. Hold throttle lever all the way back to the rear.
3. Adjust high idle stop screw until specified high idle speed 2500 RPM is obtained.
4. Connect throttle linkage.

J. Low Idle Adjustment

1. Disconnect throttle linkage to pump

2. Move throttle lever of pump forward until speed drops to 500-600 RPM

3. Turn the low idle stop screw in or out until the low idle speed of 700 RPM is obtained

    a. Lock the locking nut

Instructor check point ____________________

K. Fuel System Pressure Tests

1. Transfer pump pressure test

    a. Pressure must fall within a specified range

        (1) Check is made under no load condition

        (2) High idle speed

        (3) Engine thoroughly warmed up

    b. Install 4068 gauge block assembly and 4072 fitting into the transfer pump pressure tap

        (1) Insert 4071 compound gauge assembly into 4068 gauge block

    c. Evaluate pressure readings against manufacturer's specifications of 75-85 p.s.i.

Instructor check point ____________________

    d. Remove gauge and adapters

2. Suction side pump test

    a. Restricted fuel supply

    b. Install 4078 gauge block and hose assembly in pump inlet

    c. Insert compound gauge 4071

    d. Operate engine at high idle

    e. Read gauges for vacuum developed

        (1) Reading should be 0; with 10" H.G. maximum. Interpret readings according to manufacturer's specifications. (If reading over 10" see instructor)

Instructor check point ____________________

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3. Fuel Supply, Air leaks

   a. Operate engine at low idle

   b. Leave gauge installed in same location as for suction test above

   c. Close fuel tank valve

   d. Read gauge for vacuum developed

   e. Reading should reach at least 20 inches H.G. before engine stalls

   f. If reading less than 20 inches H.G. isolate the cause. Should hold 20" H.G. for several minutes after engine stops. Remove gauges and adapters

Inspector check point ______________________

4. Pump housing pressure test

   a. Remove pump timing plate from pump

   b. Make a small hole in timing plate gasket, if one is not already made, there.

   c. Secure 4068 gauge block, 4072 adapter and 4077 flange to side of pump

   d. Operate engine at both low and high idle

   e. Interpret reading and check manufacturer's specifications of 6 to 8 p.s.i.

Instructor check point ____________________

L. Proper use of tools

1. Accurate tool selection

2. Safe application of tools

3. Reading and Interpretation of Special tools and measuring instrutments

4. Care of tools and measuring instrutments

Instructor check point __________________

M. Cooperation with team mates

1. Gives and taks directions equally well

2. Correctly interprets instructions

3. Communicates in a friendly manner

4. Provide timely suggestions and assistance to team effort

5. Performs efficiently

Instructors check point ________________ ________

N. Shop safety

1. Handling of fuels

2. Handling of lubricants

3. Handling of batteries

4. Good housekeeping

5. Observes posted safety precautions

6. Conforms to smoking regulations

7. No sky-larking

Instructor check point ________________

Instructor Note

U.S. NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

A-610-0022

GENERAL MOTORS DIESEL ENGINE MAINTENANCE

INTRODUCTION:

A. The purpose of this job sheet is to guide you in the proper maintenance of the General Motors Diesel Engine.

B. You will perform maintenance and adjustments on the General Motors Diesel Engine.

C. You will accomplish this, using safety precautions, in accordance with manufactures specifications.

TOOLS AND EQUIPMENT:

A. Basic mechanics handtools.

B. General Motors engines

1. 6-71 inline

2. 6V-71 V Type

CONDITIONS:

A. Student teams of three (3) students each are assigned to a General Motors Diesel engine to accomplish maintenance procedures for this engine.

B. Each team is provided with all required tools and a job sheet covering the maintenance operation to be performed.

C. Preceding the shop performance all aspects of the job with necessary background theory and demonstrations by the instructor are covered in the classroom lecture/discussion.

D. YOU WILL NOT omit any of the steps in the procedure, unless told to do so by your instructor.

E. YOU WILL complete all steps in the procedure to the "Instructor Check" point DO NOT proceed beyond this point until your instructor has checked your work and initialed your job sheet.

F. Follow job sheet closely and in no way deviate from it's procedure.

G. YOU WILL obtain from the Instructor clarification of step by step procedure that you are unfamiliar with.

H. Under no circumstances will you allow tools be placed on the engine or on the deck.

I. Cleanliness should be a matter of personal pride and it is essential in the handling of engine parts and tools, also the area in which you are working. Therefore keep hands and tools wiped clean and keep the area in which you are working clean.

PROCEDURE:

NOTE: All performance will conform to manufacturer's specifications without deviation

A. Pre-start checks, starting, operating and securing "71" Series General Motors Diesel.

1. Pre-start checks

    a. Lubricating oil full

        (1) Must be checked with engine stopped

    b. Diesel fuel (3/4 or more full)

    c. Coolant

        (1) 1 inch above baffle

        (2) Leave room for expansion

    d. Position throttle

    e. Emergency shut-down valve

        (1) Make sure cable is pushed all the way in

            (a) Pull out for emergency shut down only

    f Check exposed moving parts to see that they are free from obstructions

        (1) An engine that has not been in operation should be jacked through one complete turn before starting to make sure all engine parts are free.

        (2) Observe all safety precautions for engines used in different applications.

    Instructor Check Point ______________________________

2. Starting the Engine

    a. Push in engine shut down cable

    b. Turn ignition switch to "on" position

        (1) If equipped with switch

c. Set throttle in idle position

d. Push starter switch until engine starts

(1) Never operate starter for more than 30 seconds at one time.

Instructor Check Point ______________________________

3. Operating the engine

a. As soon as engine starts, observe engine oil pressure gauge

(1) If no oil pressure within 10-15 seconds, stop engine

(2) Normal oil pressure is 30-60 psi

b. Run engine at partial throttle and no load for approximately 5 minutes to allow engine to warm up

4. Securing the engine

a. Disengage load

b. Reduce engine speed

(1) Allow engine to run at half speed or lower for 4 to 5 minutes or until temperature gauge is on lower side of operating range.

(2) Provides sufficient lubricant, water and air for uniform cooling.

Instructor Check Point ___________________________

c. Pull engine shut down cable control

(1) This places fuel control rack in the no fuel position

d. When engine stops turn ignition switch to "off", (if equipped)

(1) If switch is left "on" there is a constant drain on the battery by the instrutment panel indicators.

e. Emergency shut down.

(1) If normal shut down procedures fail; pull emergency stop control out as far as it will go.

(2) This stop cuts off combustion air from blower

(3) If emergency stop is used it must be reset manually at the blower before the engine can be restarted.

NOTE: This device is to be used only for emergency shutdown!!!

Instructor Check Point ________________________

B. Locating a Misfiring Cylinder

1. Run engine at idle speed

2. Depress follower on one injector

   a Listen for RPM change

      (1) No RPM change indicates misfiring cylinder

3. Repeat on all cylinders

Instructor Check Point ____________________

C. Changing Injectors: (Refer to sec. 2.1.1, page 4 of V-71, Detroit Diesel Maintenance, or sec 2.1 1. page 4 of in-line 71 engine Detroit Diesel Maintenance.)

1. Injector Removal:

   a. Remove valve rocker cover

   b. Remove fuel pipes from both the injector and the fuel connectors

   c Install clean shipping caps on injector inlet and outlet and on the fuel connectors

   Instructor Check Point ____________________

   d. Crank engine to bring outer ends of the push rods of the injector and valve rocker arms in line horizontally.

   Instructor Check Point ____________________

   e. Remove the two rocker arm shaft bracket bolts and swing rocker arms away from the injector and valves.

   f. Remove injector clamp (bolt or nut special washer, and clamp).

   g. Loosen the inner and outer adjusting screws on the injector rack control lever and slide the lever away from the injector

   h. Lift the injector from it's seat in the cylinder head (use lifting tool).

   i. Cover the injector hole in cylinder head to keep out foreign material

   Instructor Check Point ____________________

2. Injector installation

   a. To install injector reverse the procedure required for removal

b. Torque injector nut/bolt to 20-25 (Lb.ft.).

Instructor Check Point. ________________________

c. Torque rocker arm bracket bolt to 90-100 (LB.ft.)

Instructor Check Point ________________________

D. Valve Adjustment V-6 Engine

1. 6V engines

a. Engine at normal operating temperature (160° 185°F)

(1) Allow an additional .002" clearance when setting valves cold

b. Governor stop lever in the No Fuel position

c. Remove valve cover

d. Position engine

(1) Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

CAUTION: When using a wrench on the crankshat bolt at the front of the engine, do not turn the crankshaft in a lefthand direction of rotation as the bolt will be loosened.

e. Check valve clearance (normal operating temperature)

(1) Use .013" GO - .015" NO GO Method

f. Adjust valve clearance (cold)

(1) Loosen the push rod lock nut

(2) Place a .017" feeler gauge between the valve bridge and the valve rocker arm pallet

(3) Adjust the push rod to obtain a smooth pull on feeler gauge.

(4) Remove feeler gauge, hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

(5) Recheck the clearance. If the adjustment is correct the .015" feeler gauge will pass freely between the valve bridge and valve rocker arm pallet. But the .017" feeler gauge will not pass through.

g. Adjust remaining valves in firing order.

NOTE: SAFETY PRECAUTIONS: When a push rod has been disconnected from the rocker arm clevis, the push rod must be screwed back into the clevis until it is flush with the threaded portion of the clevis before the rocker arm is bolted back in place. Failure to do so may permit the piston to hit the head of the valve when the engine is turned over.

Instructor Check Point ______________________

E. Valve Adjustments Inline

1 Engine at normal operating temperature (160° - 185°F)

   a. Allow an additional .002" clearance when setting valves cold.

2. Place governor throttle control lever in the No Fuel position

3. Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

4. Adjust valve clearance (cold)

   a. Loosen push rod lock nut

   b. Place a .013" feeler gauge between the valve stem and the rocker arm

   c. Adjust the push rod to obtain a smooth pull on the feeler gauge.

   d. Remove feeler gauge, hold the push rod with a 5/16" wrench and tighten the lock nut with a 1/2" wrench.

   e. Recheck the clearance. If the adjustment is correct the .011" feeler gauge will pass freely between valve stem and rocker arm, but the .013" feeler gauge will not pass through.

5. Adjust remaining valves in firing order

NOTE: SAFETY PRECAUTION: Whenever a push rod has been disconnected from the rocker arm clevis, the push rod must be screwed back into the clevis until it is flush with the threaded portion of the clevis before the rocker arm is bolted back in place. Failure to do so may permit the piston to hit the head of the valve when the engine is turned over.

Instructor Check Point ______________________

F. Injector Timing

1. Use proper timing tool

   a. 1.460" - for S-70 and HV7 injectors

   1.484" - for HV6 injectors

Instructor Check Point ______________________

2. Governor stop lever in No fuel position

3. Position engine

    a Valves fully open on cylinder to be adjusted

4. Check timing dimensions

    a. Distance from top of body to top of follower

    b. Timing tool in hole on top of body

        (1) Ensure that there is no dirt in hold prior to inserting tool

    c. Hold tool perpendicular to body

        (1) The flat of the gauge toward the injector follower

    d Extended portion of gauge should just clear the top of follower

        (1) Follower too low - early injection

5. Adjust follower height

    a. Screwing push rod into clevice will permit follower to rise.

6. Time remaining injectors in firing order

Instructor Check Point ______________________________

G. Governor gap adjustment (Inline and V-6 engines)

1. To ensure that all the governor spring tension is being imparted to the weights through the lever and not to the housing.

2. Remove the governor cover

3. Place the speed control lever in the maximum speed position

4 Measure gap between governor spring plunger and plunger guide

    a. Should be .006"

5. Adjust gap

    a. Loosen the lock nut and turn the adjusting screw until a slight drag is noted on the feeler guage

6. Hold the adjusting screw and tighten the lock nut

7 Install the governor cover

Instructor Check Point ______________________

OTE: Insure that pin on governor control lever shaft sets into slot on differential lever when replacing cover.

H. Equalizing racks (V-6 Engine)

1. Position injection rack control levers with the throttle in the full fuel position.

NOTE: The letters "R" and "L" indicate the injector location in the right or left bank, viewed from the rear of the engine. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining left bank control levers.

2. Disconnect any linkage attached to the governor stop lever

3 Back out the buffer screw 5/8"

4. Loosen all of the inner and outer injector rack control lever adjusting screws on both cylinder heads and both load limit device adjusting screws.

NOTE: Be sure all injector rack control levers are "free" on the injector control tubes

5. Check for binding in the governor to control tube linkage by moving the linkage through its full range of travel with one hand on the stop lever and the other hand on one of the control tube levers.

6. Remove the clevis pin from the fuel rod at the right cylinder bank injector control tube lever

7. Move the speed control lever to the maximum speed position.

8. Move the governor stop lever to the "run" position and hold it in that position with light finger pressure

9. Turn the inner adjusting screw of the No. 1L injector rack control lever down until a slight movement in the governor stop lever is noted.

10. Screw outer screw in until it bottoms lightly on the injector control tube.

    a. Tighten inner and outer screw alternately

11. Move the governor stop lever back and forth a few times and note a "rotating" movement of the injector control rack when the stop lever is moved to the "run" position.

12. Hold the stop lever in the "run" position and using a screwdriver press downward on the injector control rack.

    a. Rack should tilt downward, and when the pressure of the screw driver is released, the control rack should "spring" back upward.

    b. Adjust the inner and outer adjusting screws to obtain this condition.

    c. At this point, No. 1L injector rack control lever is fully adjusted.

    d. Tighten both the inner and outer adjusting screws and recheck adjustment.

13. Remove clevis pin from fuel rod at the left bank injector control tube lever.

14. Insert the clevis pin in the fuel rod on the fight cylinder bank injector control tube lever.

    a. Adjust No. 1R injector rack the same way you adjusted No. 1L.

    Instructor Check Point_______________________________

15. Adjust the remaining injector rack control levers

    a. Remove clevis pin from the fuel rods and injector control tube levers.

    b. Hold injector control racks in the full-fuel position.

    c. Turn down the inner adjusting screw of the injector rack control lever until the screw bottoms (injector control rack in the full fuel position)

    d. Turn down outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

    e. While still holding control tube lever in the full-fuel position adjust the inner and outer adjusting screws to obtain the same condition as outlined in step 12.

    CAUTION: Once No. 1L and No. 1R injector rack control levers are adjusted do not try to alter their settings.

16. When all injector rack control levers are adjusted, recheck their settings.

    Instructor Check Point_______________________________

17. Insert the clevis pin in the fuel rods and the injector control tube levers.

    Instructor Check Point_______________________________

I. Equalizing racks (Inline engine)

1. Disconnect any linkage attached to the governor stop lever.

2. Back out the buffer screw 5/8".

3. Loosen all of the inner and outer injector rack control lever adjusting screws.

   Instructor Check Point_______________________________

   NOTE: Be sure all injector rack control levers are "free" on the injector control tubes.

4. Move speed control lever to maximum speed position.

5. Move the governor stop lever to the "run" position and hold it at that position with light finger pressure.

6. Turn the inner adjusting screw of the No. 1 injector rack control lever down until a slight movement in the governor stop lever is noted.

7. Screw outer screw in until it bottoms lightly on the injector control tube

   a. Tighten inner and outer screws alternately

8. Move the governor stop lever back and forth a few times and note a "rotating" movement of the injector control rack when the stop lever is moved to the "run" position.

9. Hold the stop lever in the "run" position and using a screw driver press downard on the injector control rack.

   a. Rack should tilt downward, and when the pressure of the screw driver is released, the control rack should spring back upward

   b. Adjust the inner and outer adjusting screws to obtain this condition.

   c. At this point, No. 1 injector rack control lever is fully depressed.

   d Tighten both the inner and outer adjusting screws and recheck adjusted.

   Instructor Check Point ________________________

10. Adjust the remaining injector rack control levers

    a. Remove clevis pin from the fuel rods and the injector control tube levers.

    b. Hold injector control racks in the full-fuel position

    c. Turn down the inner adjusting screw of the No. 2 injector rack control lever until the screw bottoms (injector control rack in the full-fuel position)

    d. Turn down outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

    e. While still holding control tube lever in the full-fuel position adjust the inner and outer adjusting screws to obtain the same condition as outlined in step (9).

    CAUTION!: Once No. 1 injector rack control lever is adjusted, do not try to alter the setting

11. When all injector rack control levers are adjusted recheck their settings

12. Insert the clevis pin in the fuel rod and the injector control tube lever

    Instructor Check Point________________________

J. Idle and buffer spring adjustment

   1. Start engine and run until warm

      a. Stop lever in run position

      b. Speed control lever in idle position

      Instructor Check Point ______

2 Adjust idle speed screw

   a. Loosen lock nut and turn idle speed screw until engine idles at recommended idle speed

   b. Idle speed 550 RPM

   c. Hold idle speed screw and tighten lock nut

   Instructor Check Point ______________________

3. Adjust buffer screw

   a. Engine at idle speed

   b. Turn buffer screw "IN" so that it contacts differential lever as lightly as possible and still eliminates engine roll.

   c. Hold buffer screw and tighten lock nut

   NOTE: Do not raise engine idle speed more than 15 RPM with the buffer screen

   Instructor Check Point ______________________

K. Load limit device adjustment (6V engines)

1. Mechanically limits the travel of the injector racks and thereby the fuel output of the injectors,

2. The load limiting service is adjusted after the engine turn-up is completed.

   a. Loosen load limit screw lock nut

   b. Back load limit screw out of the adjusting screw plate until 1" of the screw is below plate

   c. Adjust load limit screw lock nut so bottom of lock nut is 1-3/4" from bottom of load limit screw

   d Loosen load limit lever clamp bolts so the lever is free to turn on the injector rack control tube

   e. Thread the load limit screw into the adjusting screw plate until the lock nut "bottoms" against the top of the plate.

   f. Hold injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then, tighten the load limit lever clamp bolts

   g. Check to ensure that the injector racks will just go into the full-fuel position

h. Hold load limit screw to keep it from turning, then set the lock nut until the distance between the bottom of the lock nut and top of the adjusting screw plate:

(1) Corresponds to the marking on the adjusting screw plate

i Thread load limit screw into the plate until the lock nut "bottoms" against the top of the plate

j. Hold load limit screw to keep it from turning, then tighten the lock nut to secure the settine.

Instructor Check Point ______________________________

L. Cooperation with team mates

1. Gives and takes directions equally well
2. Correctly interprets instructions
3. Communicates in a friendly manner
4. Provides timely suggestions and assistance to team effort
5. Performs efficiently

Instructor Check Point ______________________

M. Shop safety

1. Handling of fuels
2. Handling of lubricants
3. Handling of batteries
4. Good housekeeping
5. Observes posted safety regulations
6. Conforms to smoking regulations
7. No skylarking

Instructor Check Point ________________________

N. Use of tools

1. Accurate tools selection

2. Safe application of tools
3. Reading and interpretation of special tools and measuring instruments
4. Care of tools and measuring instruments

Instructor Check Point ______________________

INSTRUCTOR"S NOTES: ______________________

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NAVAL SCHOOLS CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

CMA.JS.2.4.1.1

COURSE A-610-0022

Diesel

TITLE: Maintenance of Cummins N.H. Diesel Engines

INTRODUCTION:

A. The purpose of this job sheet is to guide you in the proper maintenance of the Cummins NH-250 diesel engine.

B. You will perform maintenance and adjustments on the Cummins NH-250 diesel engine.

C. You will accomplish this, using safety precautions, in accordance with manufactures specifications.

TOOLS AND EQUIPMENT:

A. Basic mechanics handtools

B. Cummins NH-250 engines

CONDITIONS:

A. Student teams of three (3) students each are assigned to a Cummins NH-250 diesel engine to accomplish maintenance procedures for this engine.

B. Each team is provided with all required tools and a job sheet covering the maintenance operation to be performed.

C. Preceding the shop performance all aspects of the job with necessary background theory and demonstrations by the instructor are covered in the classroom lecture/discussion.

D. You will not omit any of the steps in the procedure, unless told to do so by your instructor.

E. You will complete all steps in the procedure to the "Instructor Check" point. DO NOT proceed beyond this point until you instructor has checked your work and initialed your job sheet.

F. You will follow job sheet closely and in no way deviate from its procedure.

G. You will obtain from the Instructor clarification of step by step procedure that you are unfamiliar with.

H. Under no circumstances will tools be placed on the engine or on the deck.

I. Cleanliness should be a matter of personal pride and it is essential in the handling of engine parts and tools, also the area in which you are working. Therefore, keep hands and tools wiped clean and keep the area in which you are working clean.

PROCEDURE:

NOTE: All student performance will conform to manufactures specifications.

A. Pre-start checks

1. Lubricating oil
2. Diesel fuel
    a. Adequate supply
3. Coolant
    a. Full
4. Hand Cranking
    a. Bar engine through two (2) complete revolutions.
        (1) To reveal frozen parts or liquid in cylinder.
    b. Do not attempt to start engine by hand cranking.

Instructor check point____________________

5. Throttle position for starting
    a. Idle position
6. Manual solenoid control
    a. Closed position
7. Electrical solenoid control
    a. Open position
8. Check exposed moving parts for possible obstructions
    a. Check completely around engine

Instructor check point____________________

B. Starting, operating and securing

1. Pull compression release (if so equipped)
2. Push starter button
3. Close compression release (if so equipped)
    a. After 3 or 4 seconds of cranking

4. Release starter button when engine starts

   a. Never use starting motor more than 30 seconds before allowing it to cool 2-5 minutes

5. Operating

   a. Check gauges

      (1) Lube oil pressure 20-70 psi

      (2) Generator charging rate

   b. Listen for unusual noises

   c. Warm up speed

      (1) 800 - 1000 RPM

   d. Accelerating and decelerating quickly

      (1) Permissible if situation warrants

      (2) No permissible for "Hot Rod" effect

         (a) Causes unnecessary engine wear and twisting effort on crankshaft

Instructor check point ____________

6. Securing

   a. Remove all load from engine

   b. Idle engine for 3 to 5 minutes

      (1) Cools off engine hot spots

   c. Turn off fuel solenoid switch

      (1) Never use compression release mechanism to secure engine

         (a) Excessive wear will occur on push rod sockets

   d. Emergency shut down

      (1) Pt pump

         (a) Use manual shut down switch, or over-ride

Instructor check point ______________

C. Service fuel pump filter

1. Remove screen and magnet

    a. Clean screen with compressed air

    b. Wash magnet off in solvent or clean diesel fuel.

2. Replace magnet and screen in pump

Instructor check point ________________

D. Belt adjustment

1. Belt tightening procedure

    a. With index finger extended straight out from the hand depress belt at midpoint between pulleys

    NOTE: This pressure equals approximaely 13 pounds to belt

    b. Determine permissible deflection based on belt width and span between pulleys as shown in table below:

BELT TENSION

BELT WIDTH	DEFLECTION PER FT. OF SPAN
1/2"	13/32"
11/16"	13/32"
3/4"	7/16"
7/8"	1/2"
1"	9/16"

    c. Adjusting tension (pump mounted fan)

        (1) Eccentric mounted water pump

            (a) Loosen water pump bolts

            (b) Rotate water pump body in bore until belts have required tension

    d. Adjusting tension (bracket mounted fan)

        (1) Loosen adjusting bolt in mounting bracket move bracket to obtain proper tension.

    e. Water pump drive belts (pump mounted on eccentric)

        (1) Loosen pump bolts

(2) Rotate pump inside bore to obtain proper tension according to table above.

Instructor check point ________________

E. Servicing scavenging system

1. Pre-cleaner - construction equipment

   a. Remove jar or pan

   b. Dump out dirt wipe or blow clean and replace jar or pan on equipment

2. Air and vapor line connections

   a. Check connections for leaks

      (1) Tighten or repair as required

3. Air cleaner dry type

   a. Clean with compressed air

      (1) Use care not to puncture paper element

   b. Inspect element for holes

      (1) Element should be replaced if it has holes or other damage

4. Crankcase ventilator

   a. Oil bath type

      (1) Remove from engine

      (2) Drain oil

      (3) Wash screen and oil cup in solvent

         (a) Blow dry with compressed air

      (4) Refill oil cup to proper level

      (5) Reinstall on engine

   b. Paper type are replaced not cleaned

Instructor check point ______________

F. Valve adjustment

1. Position no. 1 cylinder for valve adjustment

   a. Bar engine in direction of rotation until intake valve on no. 6 cylinder starts to open (push rod tightens)

   b. Continue to rotate engine until 1-6 vs mark on accessory drive pulley alighs with pointer

      (1) In this position both the intake and exhaust valves will be closed on cylinder no. 1 (push rods free)

Instructor check point ______________

2. Valve crosshead adjustment

   a. Loosen the adjusting screw lock nut and back off the adjusting screw one turn

   b. Use light finger pressure at the rocker lever contact surface to hold crosshead in contact with the valve stem nearest the push rod

   c. Turn the adjusting screw down until it contacts its mating valve stem

   d. For new crosshead and guides, advance the adjusting screw 20° more to straighten the stem in its guide. Worn crossheads may be advanced 30° to straighten the stem in its guide

   e. Hold the adjusting screw in this position and tighten lock nut to specified torque: 25/30 foot-pounds

Instructor check point ______________

3. Valve adjustments

   a. The same engine position used in setting the crossheads is used for setting the intake and exhaust valves.

   b. Make sure that the compression release is in the run position before setting the intake valves

   c. Turn adjusting screw to obtain specified clearance between the rocker lever and the valve crosshead. Tighten locknut to specified torque

      NOTE: Always make final adjustments of the valves and injectors with the engine oil temperature at 140°

      (1) Valve setting hot intake .013"GO .015" NO GO
                                  exhaust .026" GO .028" NO GO
          Deduct 2 points for each .001" variation from specified clearance

4. Continue crosshead and valve adjustments in firing order sequence 1-5-3-6-2-4

Instructor check point ______________

G. Use of tools

1. Accurate tool selection
2. Safe application of tools
3. Reading and interpretation of special tools and measuring instruments
4. Care of tools and measuring instruments

Instructor check point ________________

H. Cooperation with team mates

1. Gives and takes directions equally well
2. Correctly interprets instructions
3. Communicates in a friendly manner
4. Provides timely suggestions and assistance to team effort
5. Performs efficiently

Instructor check point ________________

I. Shop safety

1. Handling of fuels
2. Handling of lubricants
3. Handling ob batteries
4. Good housekeeping
5. Observes posted safety precautions
6. Conforms to smoking regulations
7. No skylarking

Instructor check point ________________